US009400485B2

(12) United States Patent
Okano et al.

(10) Patent No.: US 9,400,485 B2

(45) Date of Patent: Jul. 26, 2016

(54) COOLING DEVICE HAVING A TURBULENCE GENERATING UNIT

(71) Applicants: **Satoshi Okano**, Kanagawa (JP); **Takayuki Nishimura**, Tokyo (JP); **Kenichi Takehara**, Kanagawa (JP); **Yasuaki Iijima**, Kanagawa (JP); **Hiromitsu Fujiya**, Kanagawa (JP); **Tomoyasu Hirasawa**, Kanagawa (JP); **Masanori Saitoh**, Tokyo (JP); **Shingo Suzuki**, Kanagawa (JP); **Keisuke Yuasa**, Kanagawa (JP); **Keisuke Ikeda**, Kanagawa (JP)

(72) Inventors: **Satoshi Okano**, Kanagawa (JP); **Takayuki Nishimura**, Tokyo (JP); **Kenichi Takehara**, Kanagawa (JP); **Yasuaki Iijima**, Kanagawa (JP); **Hiromitsu Fujiya**, Kanagawa (JP); **Tomoyasu Hirasawa**, Kanagawa (JP); **Masanori Saitoh**, Tokyo (JP); **Shingo Suzuki**, Kanagawa (JP); **Keisuke Yuasa**, Kanagawa (JP); **Keisuke Ikeda**, Kanagawa (JP)

(73) Assignee: **Ricoh Company, Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 248 days.

(21) Appl. No.: **14/075,850**

(22) Filed: **Nov. 8, 2013**

(65) **Prior Publication Data**

US 2014/0064775 A1 Mar. 6, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/844,384, filed on Jul. 27, 2010, now Pat. No. 8,606,138.

(30) **Foreign Application Priority Data**

Aug. 5, 2009	(JP)	2009-182895
Aug. 5, 2009	(JP)	2009-182899
Nov. 11, 2009	(JP)	2009-257656

(51) **Int. Cl.**

G03G 15/20 (2006.01)
G03G 21/20 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***G03G 21/20*** (2013.01); ***F28D 7/12*** (2013.01); ***F28F 1/405*** (2013.01); ***F28F 5/02*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC F28F 1/405; F28D 7/12

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,100,631 A * 8/1963 Schmidt F27D 3/026 165/89

3,633,663 A 1/1972 Tafel

(Continued)

FOREIGN PATENT DOCUMENTS

JP 1-136279 U 9/1989

JP 2-25333 A 1/1990

(Continued)

OTHER PUBLICATIONS

Office Action issued Apr. 26, 2013 in Japanese Patent Application No. 2009-182895.

(Continued)

Primary Examiner — David Gray

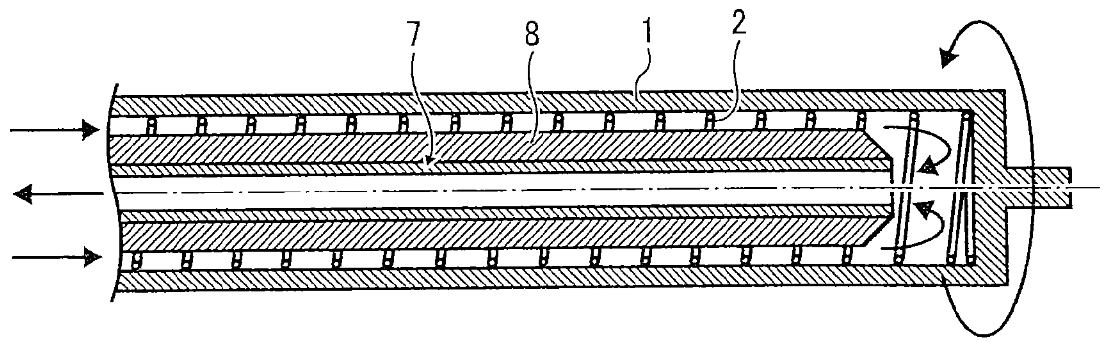
Assistant Examiner — Geoffrey Evans

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

In a cooling device that includes a cooling roller that comprises a hollow tubular member and a cooling medium transport unit for transporting a cooling liquid to the inside of the cooling roller and contacts a sheet-like member to cool down the paper, a turbulence generating unit that generates turbulence in a cooling liquid is disposed near an inner wall of the outer tube.

20 Claims, 31 Drawing Sheets



(51) **Int. Cl.**

F28D 7/12	(2006.01)
F28F 1/40	(2006.01)
F28F 5/02	(2006.01)
F28F 13/12	(2006.01)
F28F 13/08	(2006.01)
F28D 7/10	(2006.01)
F28F 13/06	(2006.01)

(52) **U.S. Cl.**

CPC ***F28F 13/12*** (2013.01); ***G03G 15/2014*** (2013.01); *F28D 7/10* (2013.01); *F28F 13/06* (2013.01); *F28F 13/08* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,870,100	A	3/1975	Korting et al.	
3,976,423	A	8/1976	Schmidt	
4,315,299	A	2/1982	Saint Marcoux et al.	
4,351,386	A	9/1982	Kobler	
4,658,486	A *	4/1987	Schonemann	D21F 5/022 162/121
4,913,224	A	4/1990	Moran	
5,271,456	A *	12/1993	Baumann	F26B 13/183 165/90
5,437,819	A	8/1995	Hardison	
5,899,264	A *	5/1999	Marschke	D21F 5/10 165/89
6,675,876	B2	1/2004	Yamashita et al.	
7,025,123	B1	4/2006	Gerndt et al.	
7,352,979	B2	4/2008	Funabiki et al.	
7,420,141	B2	9/2008	Kitano et al.	
7,725,055	B2	5/2010	Smeyers et al.	
8,306,449	B2	11/2012	Stresau	
8,351,817	B2 *	1/2013	Saitoh	G03G 15/6573 165/89
9,098,024	B2 *	8/2015	Ikeda	
9,217,979	B2 *	12/2015	Hirasawa	G03G 15/6473
2002/0005152	A1 *	1/2002	Namba	F23G 5/006 110/210
2002/0058225	A1 *	5/2002	Namba	F23G 5/006 432/219
2009/0156379	A1	6/2009	Rodal	
2010/0008694	A1	1/2010	Okano et al.	
2010/0008695	A1	1/2010	Okano et al.	
2010/0129107	A1	5/2010	Takehara et al.	
2010/0260513	A1 *	10/2010	Kawasaki	G03G 5/00 399/96
2011/0052248	A1	3/2011	Nishimura et al.	
2011/0052249	A1	3/2011	Iijima et al.	
2012/0180999	A1 *	7/2012	De Santi	F28F 1/405 165/109.1
2012/0315069	A1	12/2012	Ikeda et al.	
2015/0354857	A1 *	12/2015	Speake	F24J 2/4647 126/640
2016/0026125	A1 *	1/2016	Ishii	G03G 15/2017 399/341

FOREIGN PATENT DOCUMENTS

JP	3-36832 U	4/1991		
JP	5-33112 A	2/1993		
JP	8-129310	5/1996		
JP	8-338890 A	12/1996		
JP	10-207155	8/1998		
JP	11-7218	1/1999		
JP	2000-75709	3/2000		
JP	2000-196276	7/2000		
JP	2005-298109	10/2000		
JP	2002-229366	8/2002		
JP	3478676	10/2003		
JP	2004-285952 A	10/2004		
JP	2005-234205	9/2005		
JP	2005-234206	9/2005		
JP	2005-292578	10/2005		
JP	2005-292594	10/2005		
JP	2006-3819 A	1/2006		
JP	2006-58493	3/2006		
JP	2006-91095	4/2006		
JP	2006-225115	8/2006		
JP	2006-258953	9/2006		
JP	2007-78917	3/2007		
JP	2007-119109	5/2007		
JP	3987399	7/2007		
JP	4265996	2/2009		
JP	WO 2009072667 A1 *	6/2009		G03G 5/00
JP	4380559	10/2009		
JP	4445336	1/2010		

OTHER PUBLICATIONS

Office Action issued May 17, 2013 in Japanese Patent Application No. 2009-182899.

Office Action issued May 17, 2013 in Japanese Patent Application No. 2009-257656.

English machine translation of Takahashi (JP 2000-196276A); Electronic Apparatus; published Jul. 14, 2000; by Takahashi, Masahiro.

Chinese Office Action issued Feb. 24, 2012, in Patent Application No. 201010247336.X (with English-language translation).

* cited by examiner

FIG. 1A

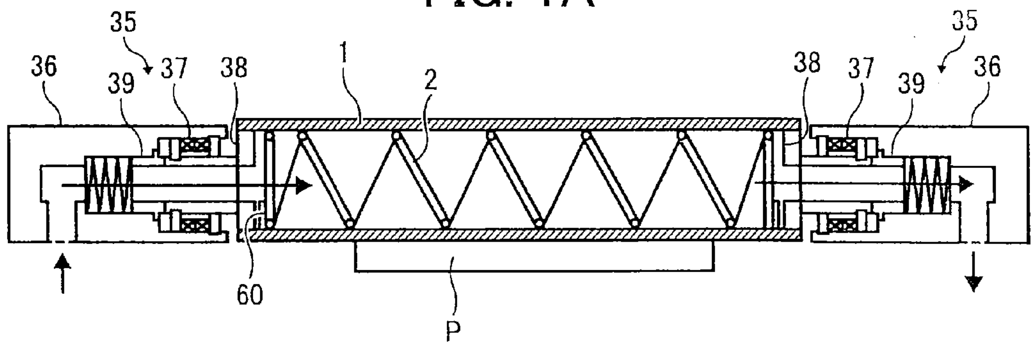


FIG. 1B

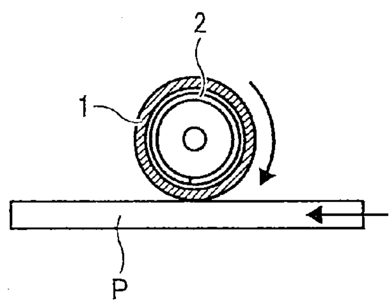


FIG. 2

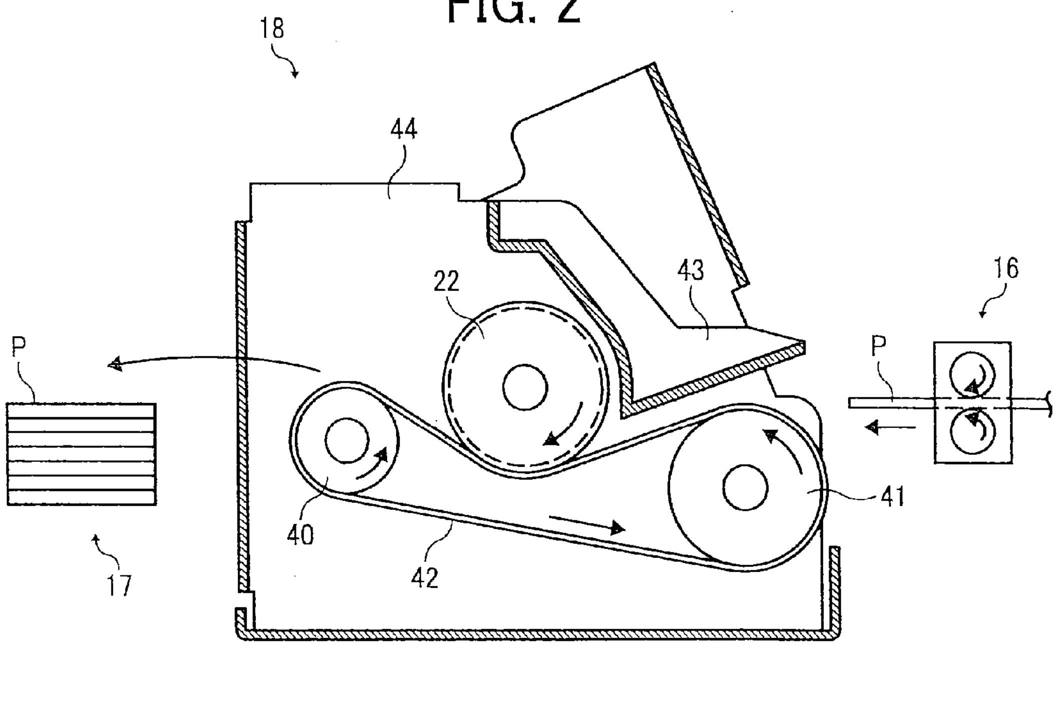


FIG. 3

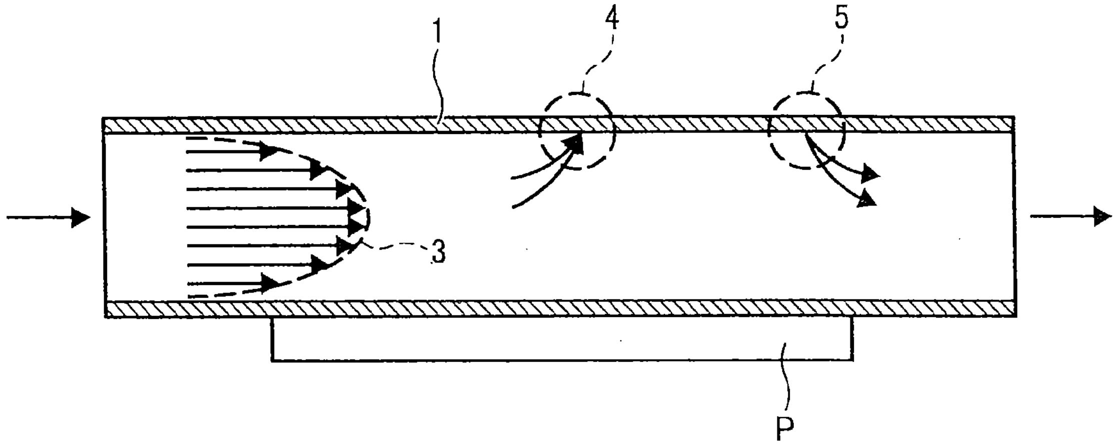


FIG. 4

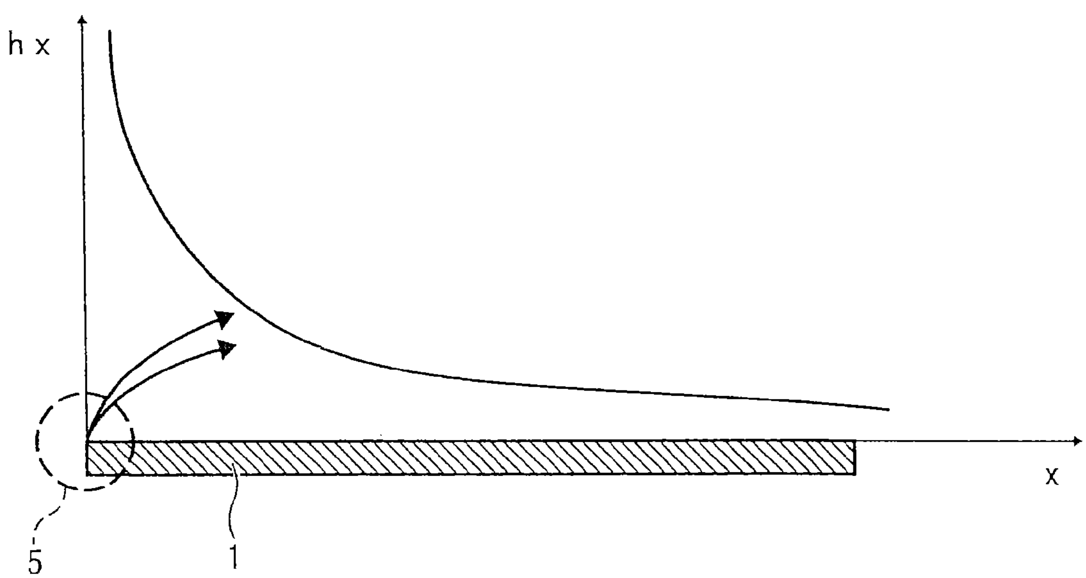


FIG. 5A

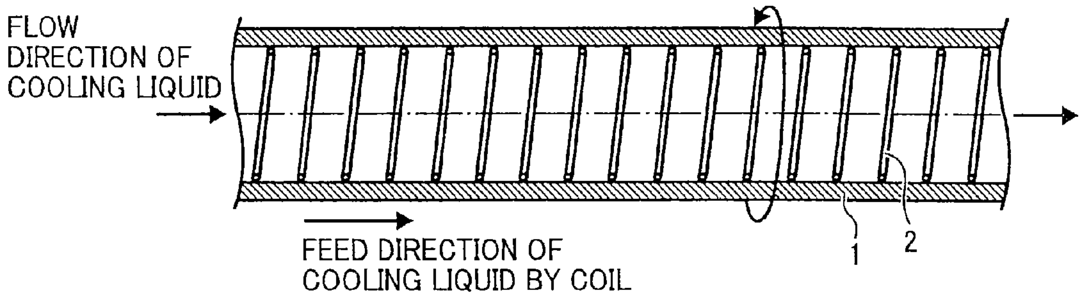


FIG. 5B

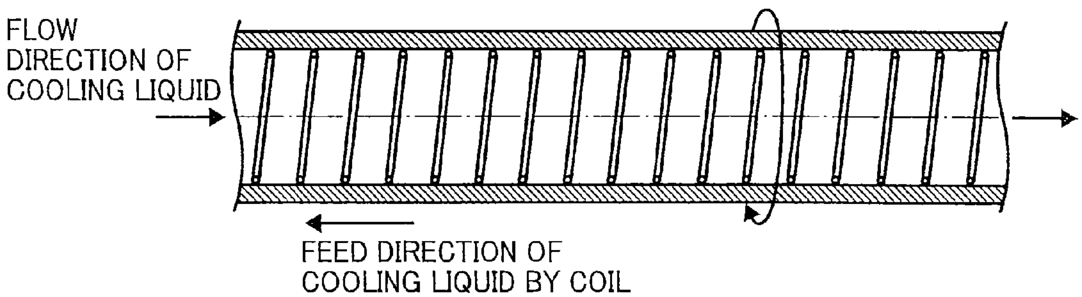


FIG. 5C

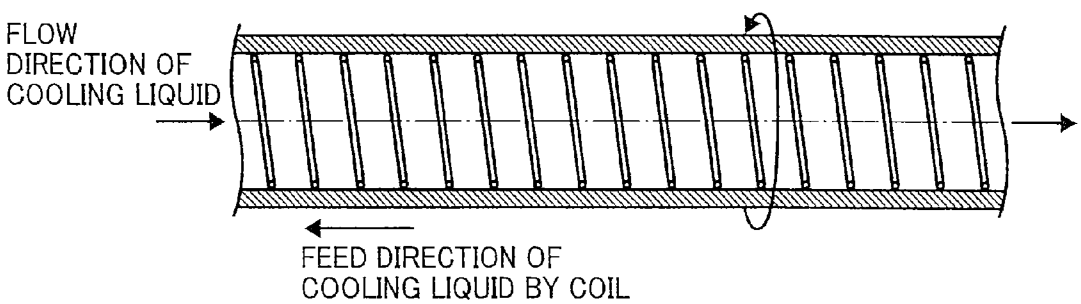


FIG. 5D

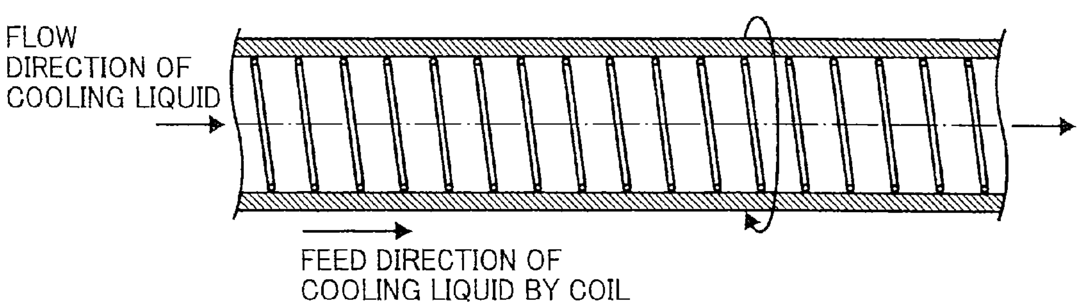


FIG. 6

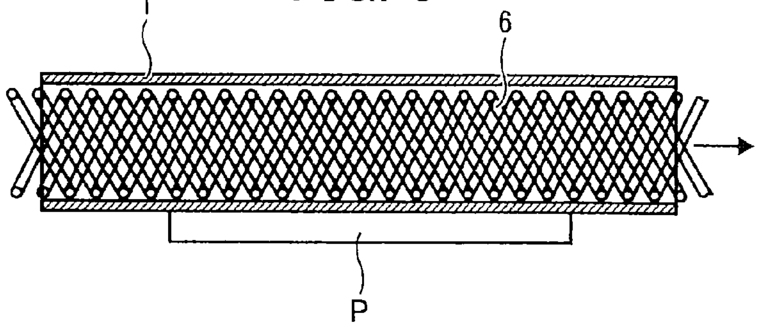


FIG. 7

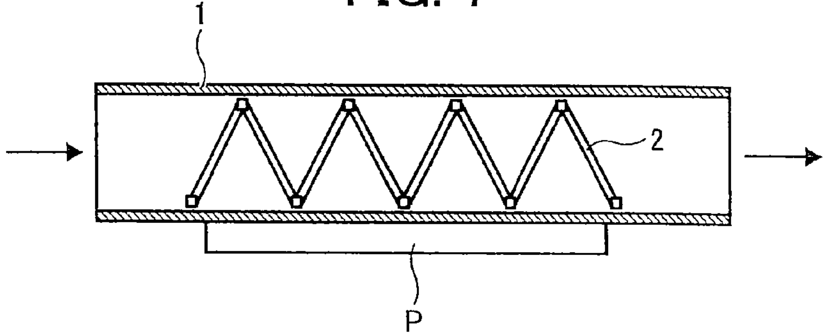


FIG. 8A

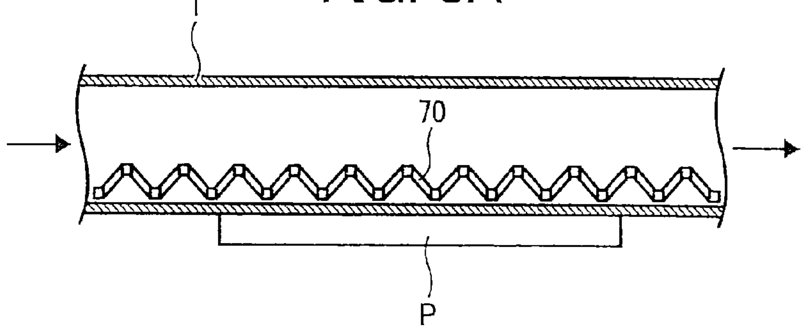


FIG. 8B

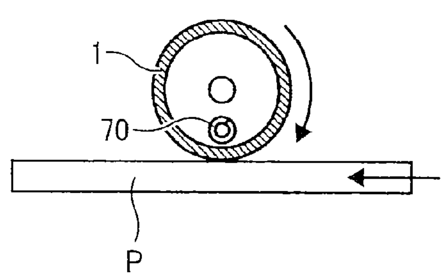


FIG. 9

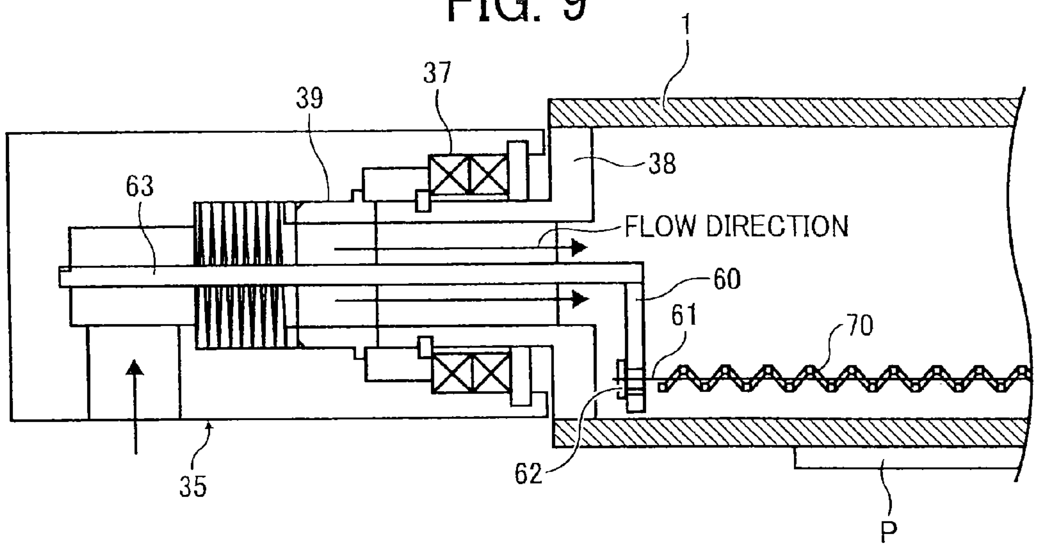


FIG. 10

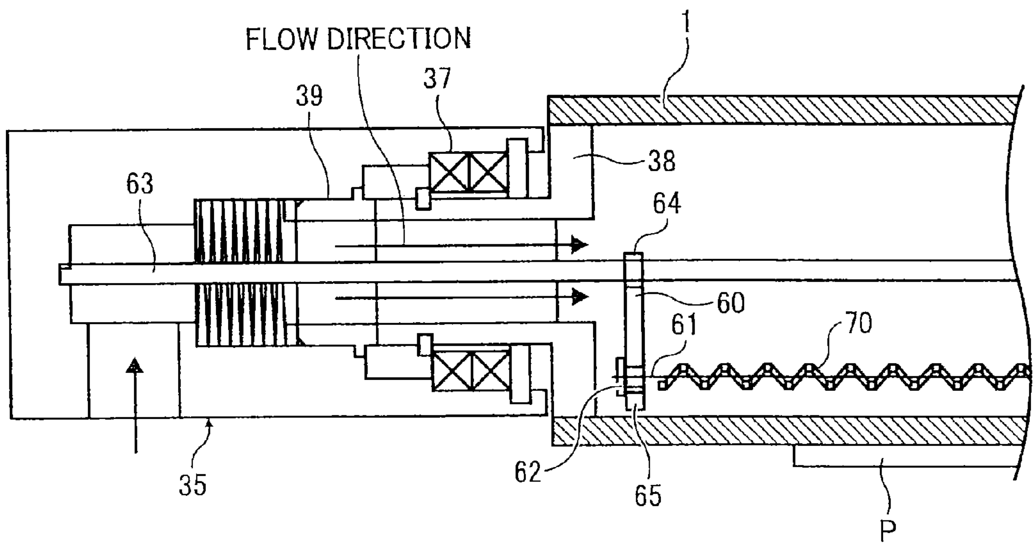


FIG. 11

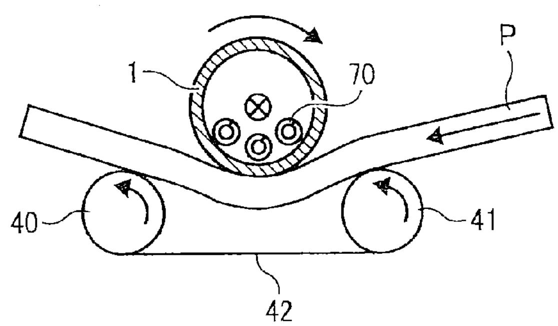


FIG. 12

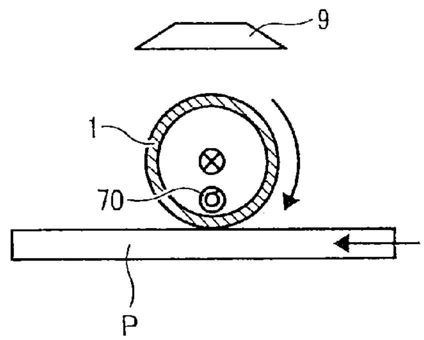


FIG. 13A

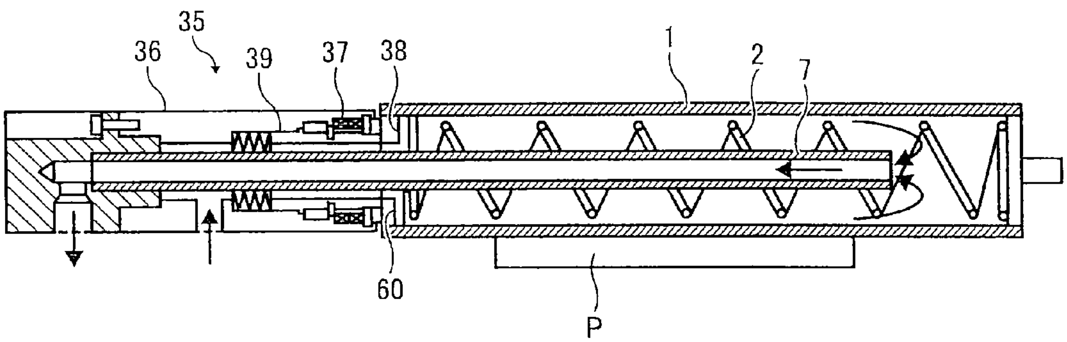


FIG. 13B

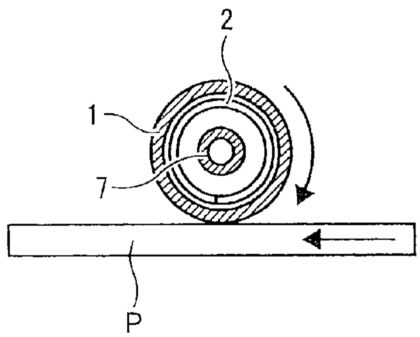


FIG. 14A

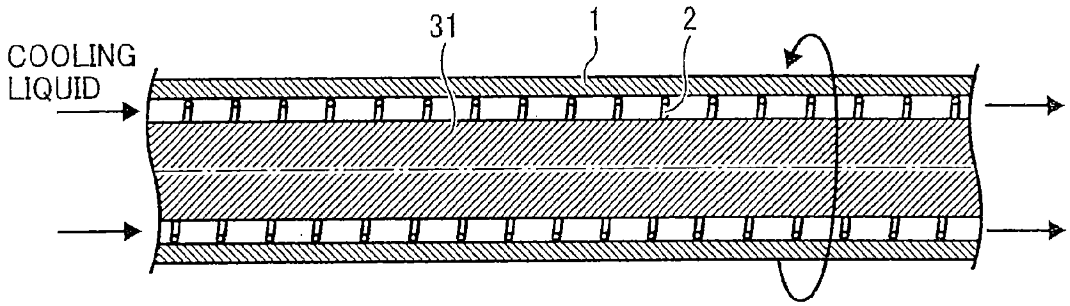


FIG. 14B

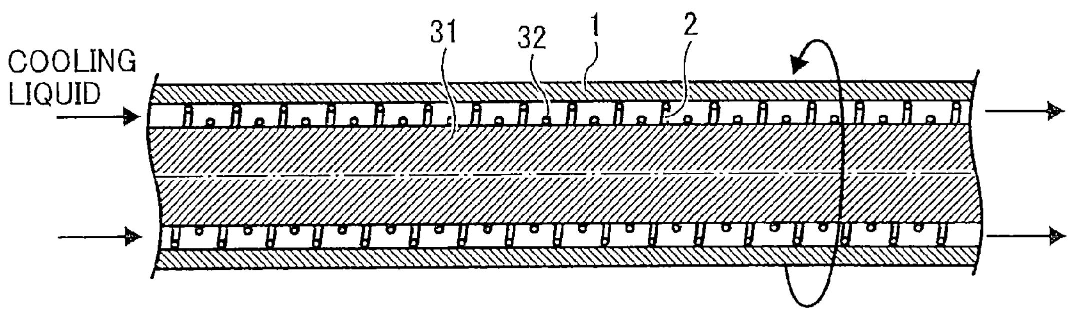


FIG. 15

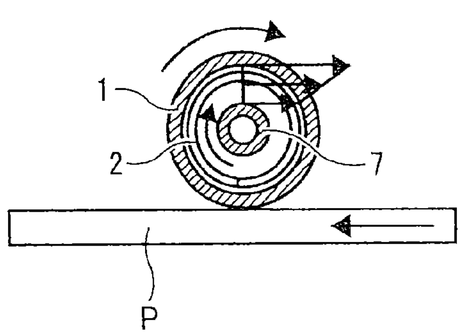


FIG. 16

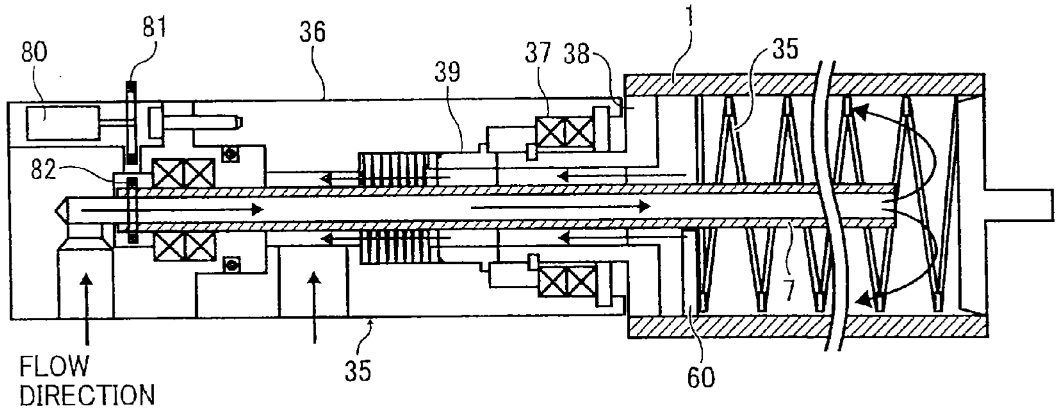


FIG. 17A

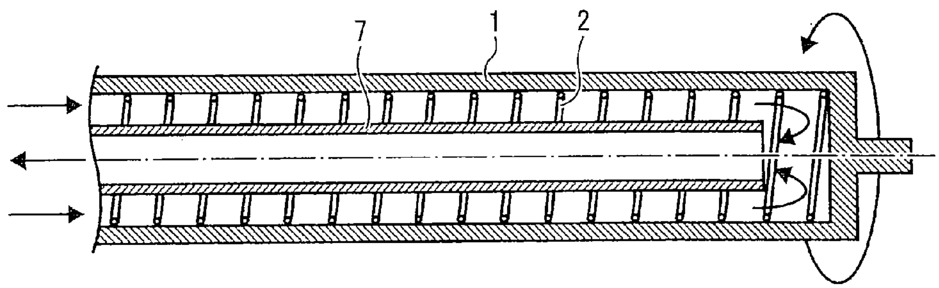


FIG. 17B

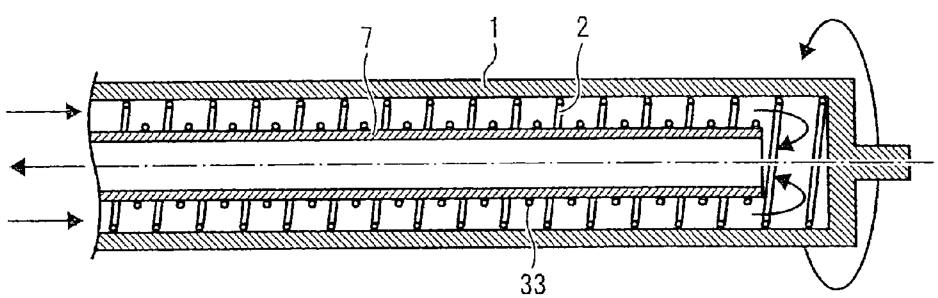


FIG. 18

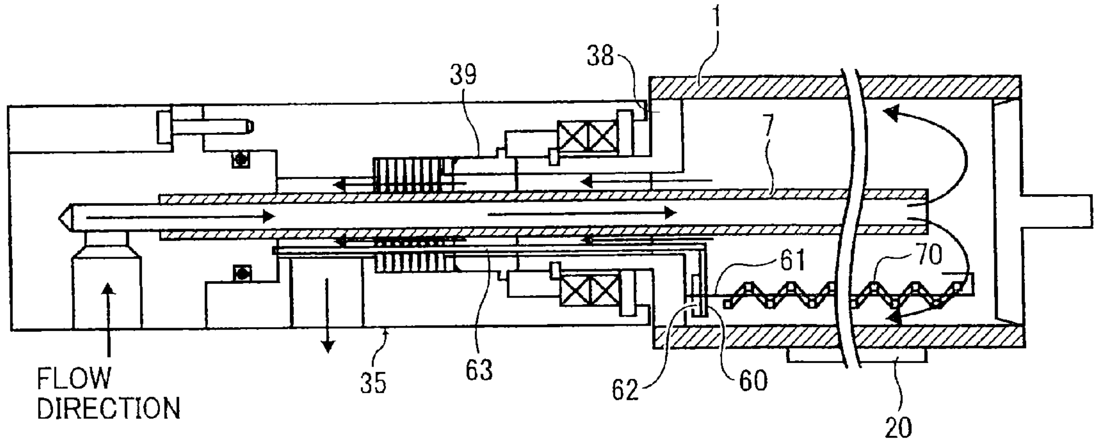


FIG. 19

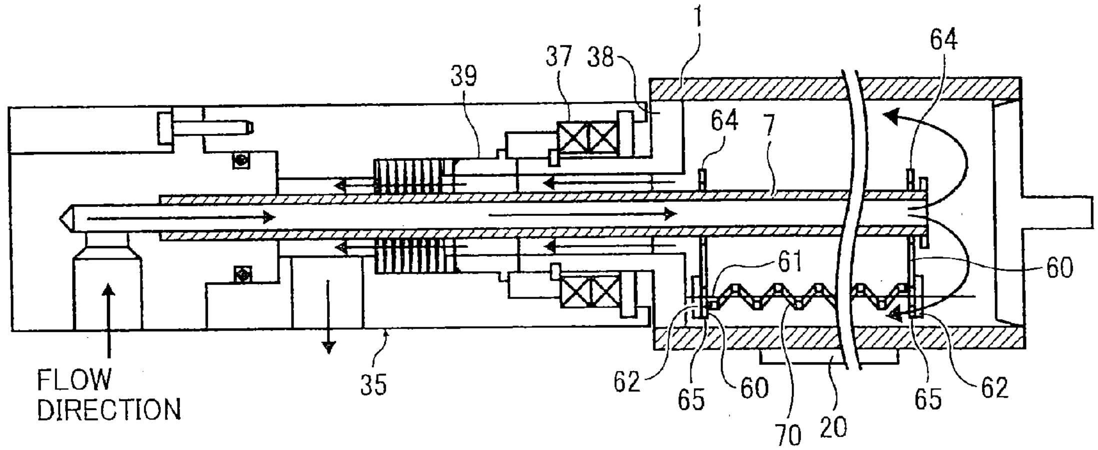


FIG. 20A

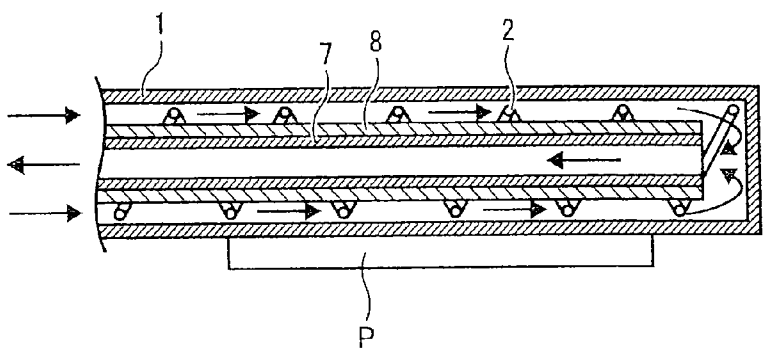


FIG. 20B

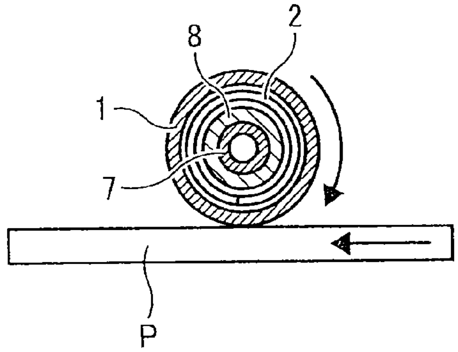


FIG. 21A

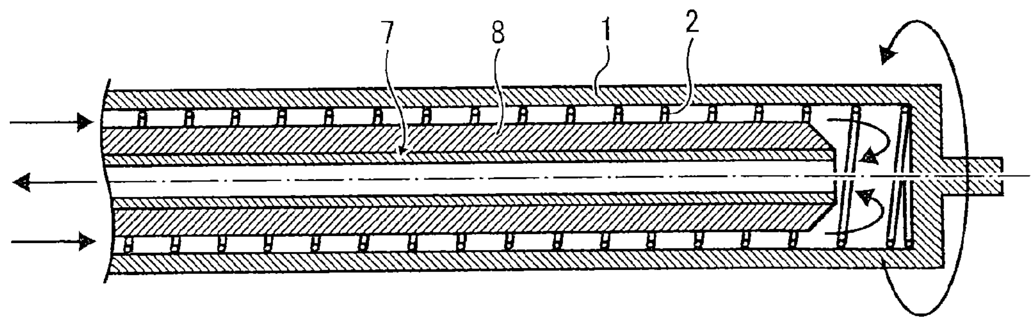


FIG. 21B

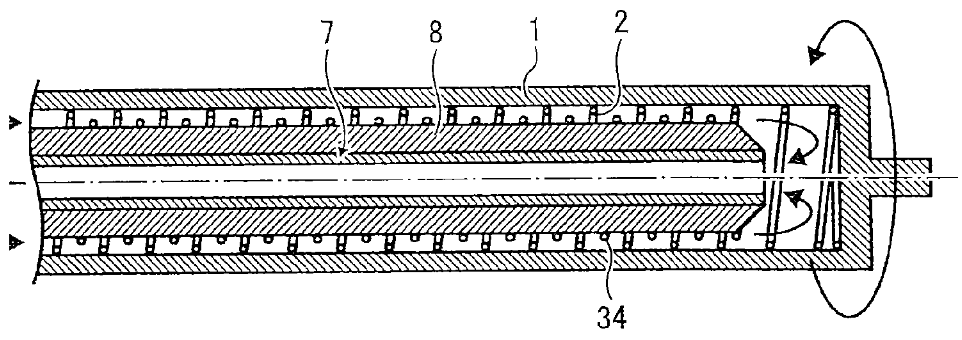


FIG. 22

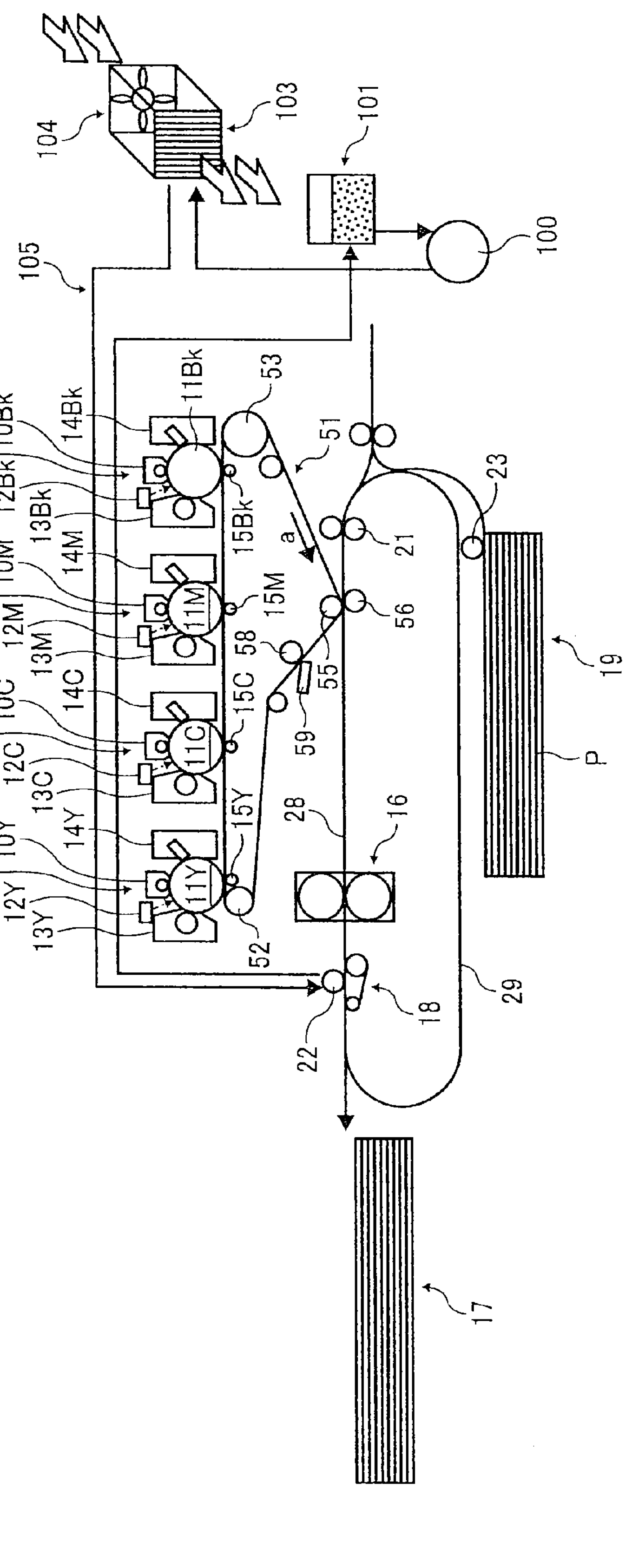

104
103
101
100
105
54Bk
12Bk
13Bk
10Bk
14Bk
11Bk
15Bk
53
51
a
54M
12M
13M
10M
14M
11M
15M
54C
12C
13C
10C
14C
11C
15C
54Y
12Y
13Y
10Y
14Y
11Y
15Y
21
23
56
58
55
59
19
P
28
16
52
18
29
22
17

FIG. 23

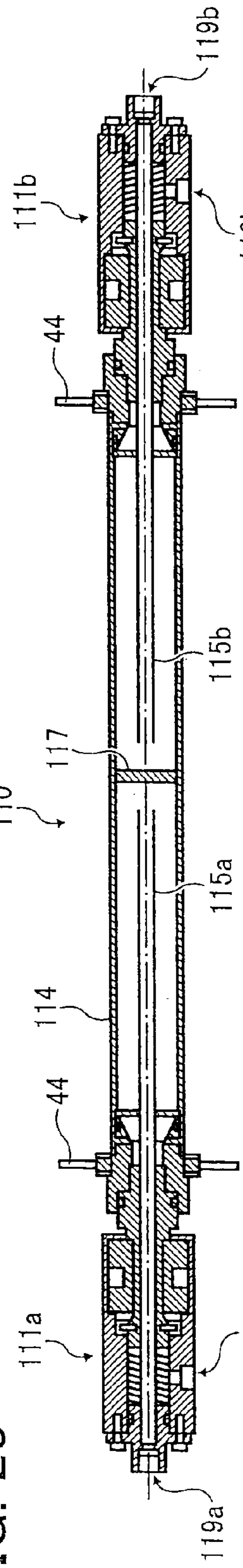

119b
111b
113b
44
115b
117
110
115a
114
44
111a
113a
119a

FIG. 24

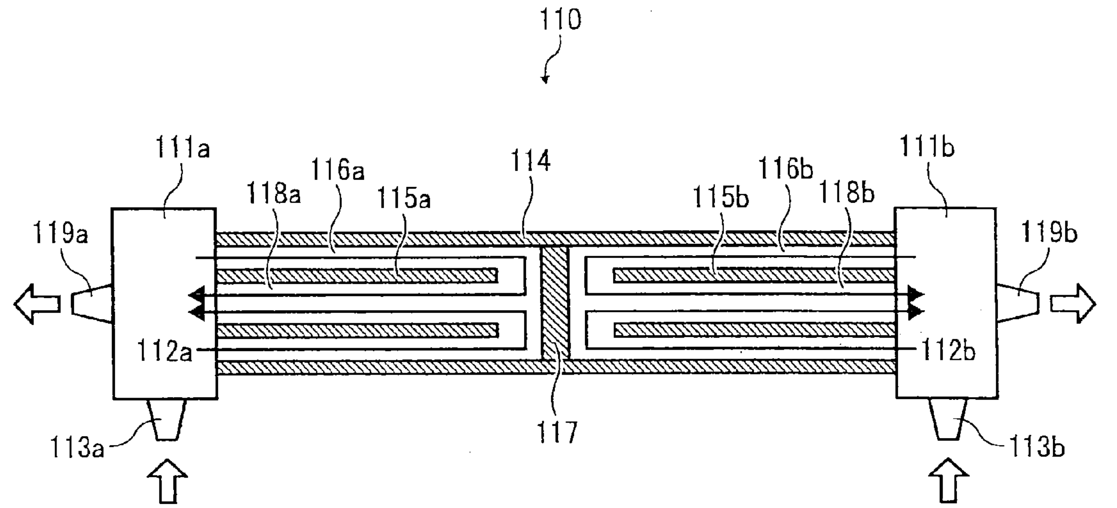

110
111a
116a
114
116b
111b
118a
115a
115b
118b
119a
119b
112a
112b
113a
117
113b

FIG. 25

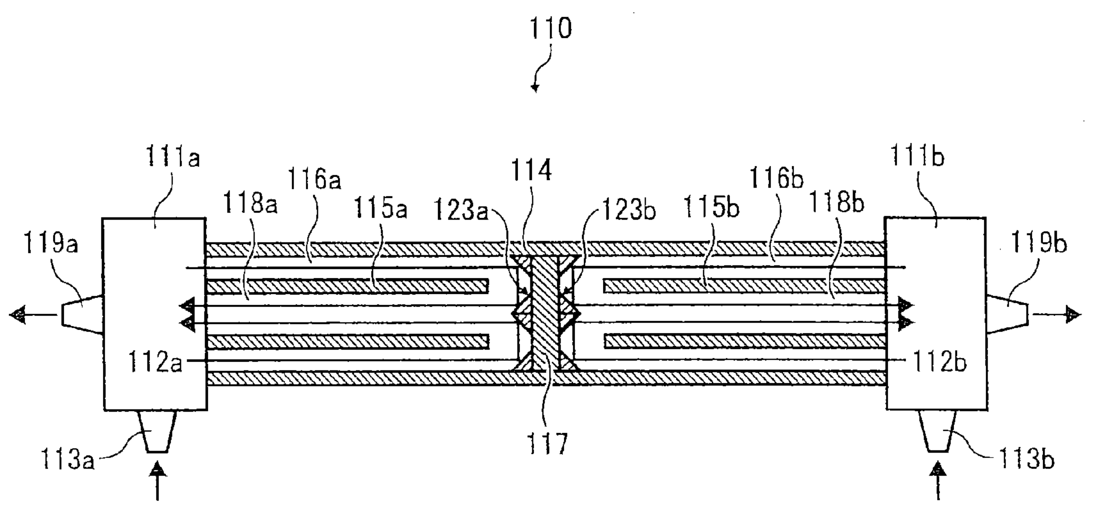

110
111a
116a
114
116b
111b
118a
115a
123a
123b
115b
118b
119a
119b
112a
112b
117
113a
113b

FIG. 26A

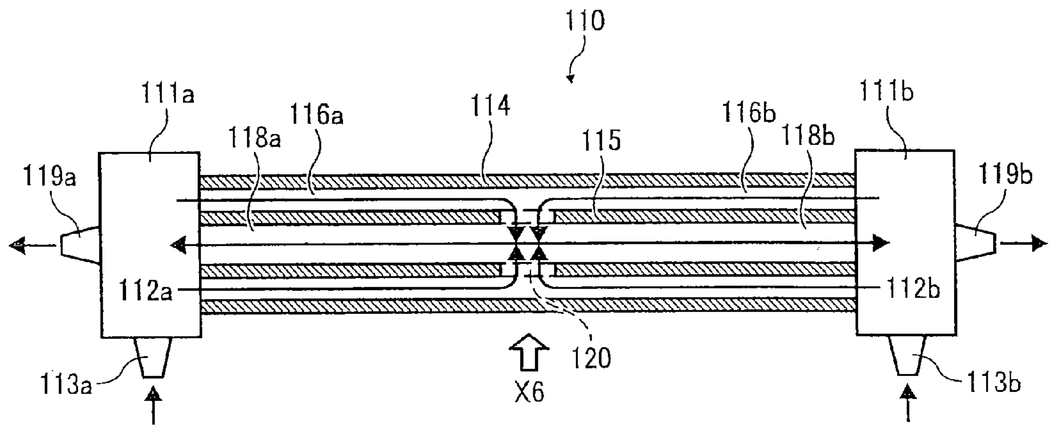


FIG. 26B

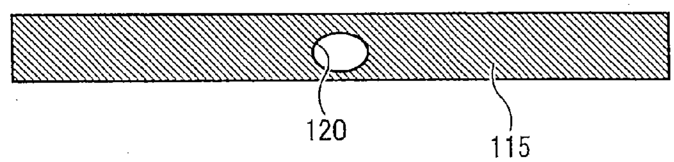


FIG. 27A

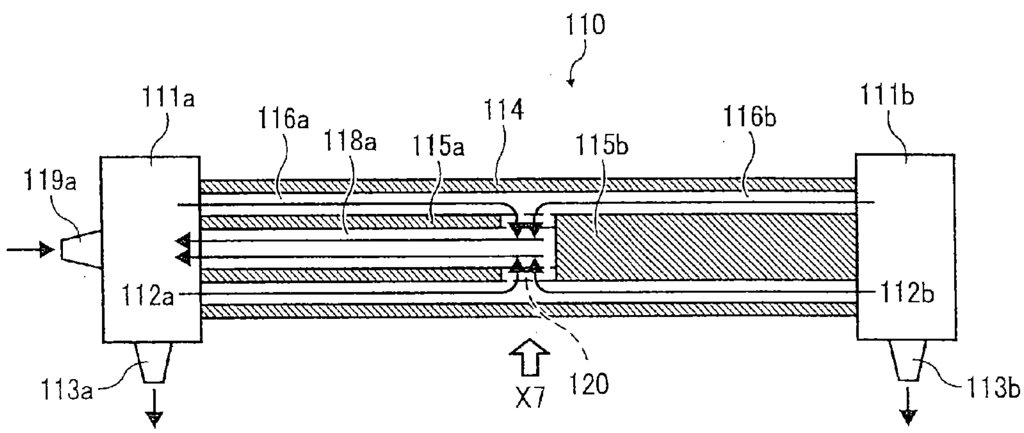


FIG. 27B

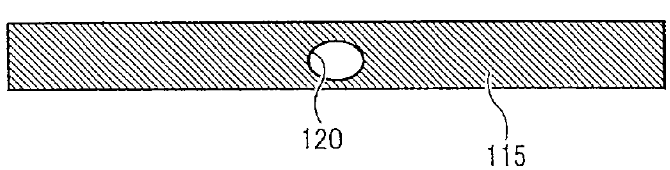


FIG. 28

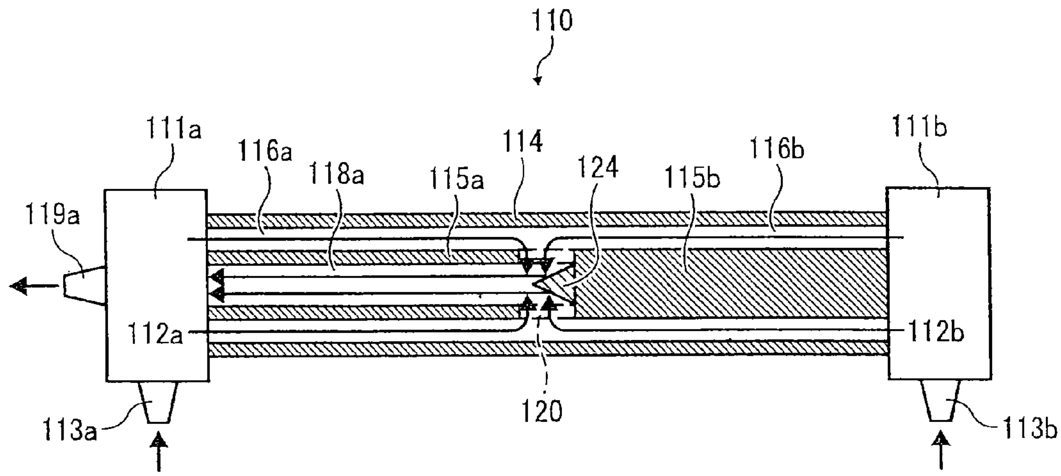


FIG. 29A

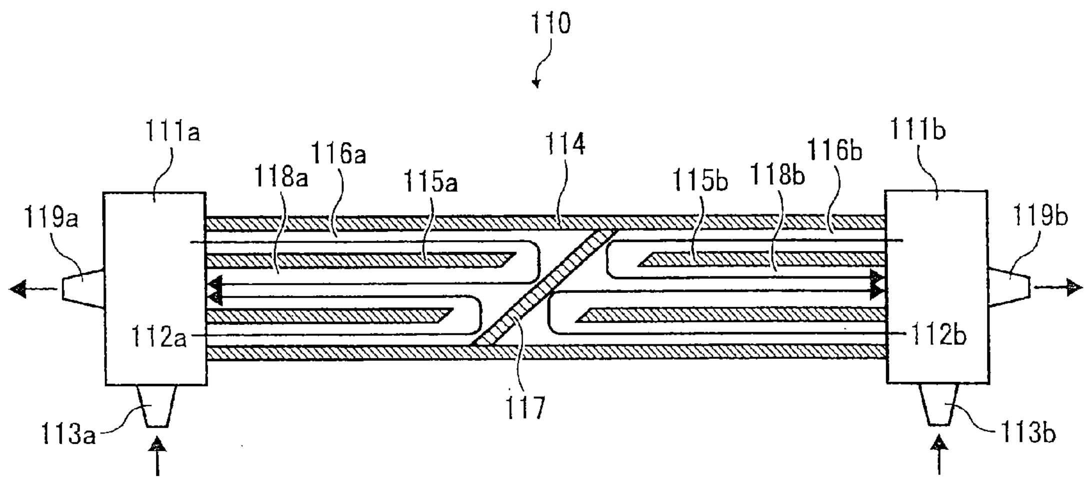


FIG. 29B

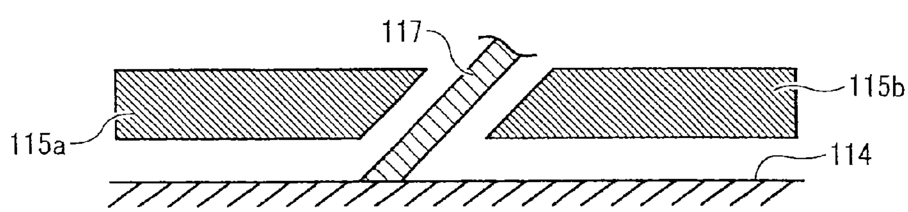


FIG. 30A

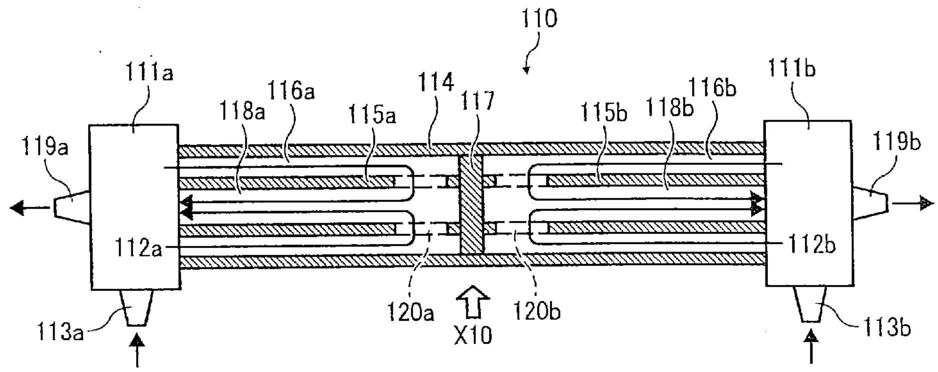


FIG. 30B

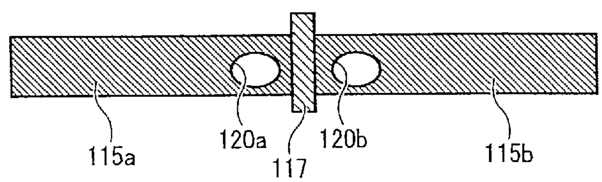


FIG. 31A

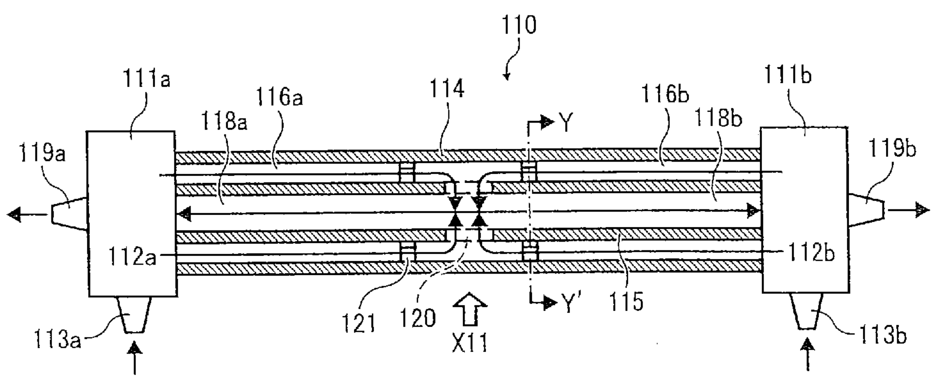


FIG. 31B

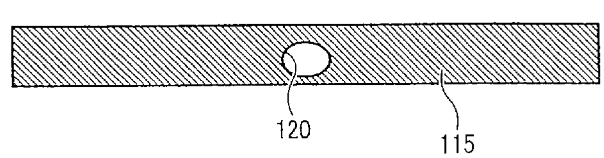


FIG. 32

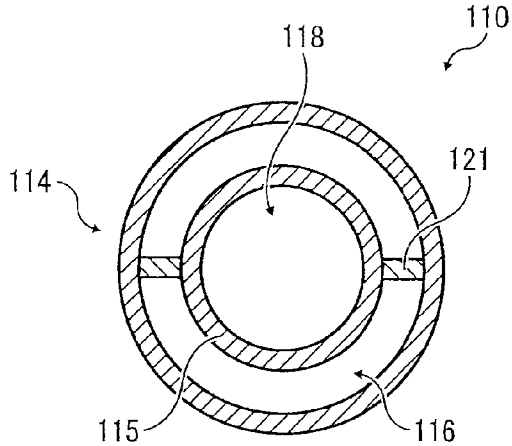


FIG. 33A

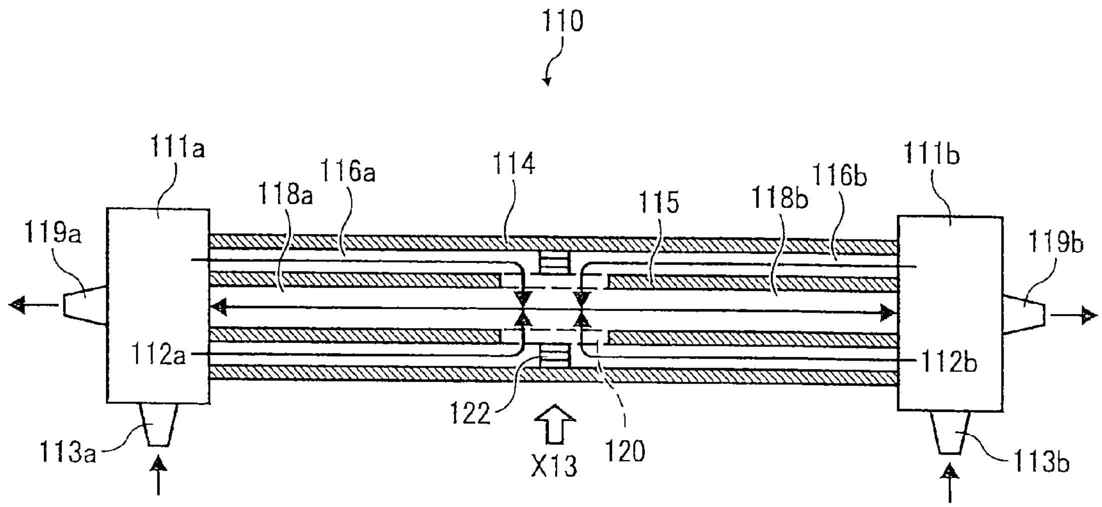


FIG. 33B

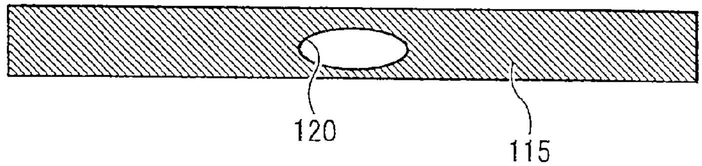


FIG. 34

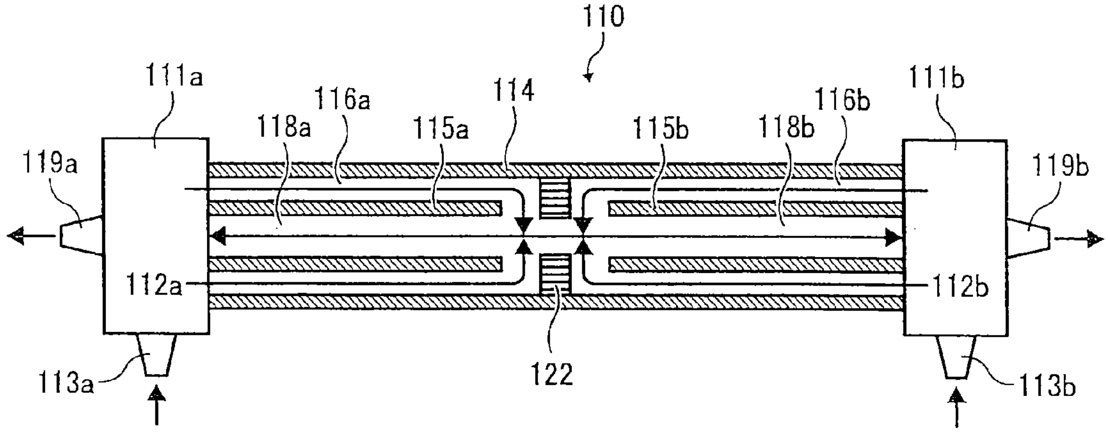


FIG. 35A

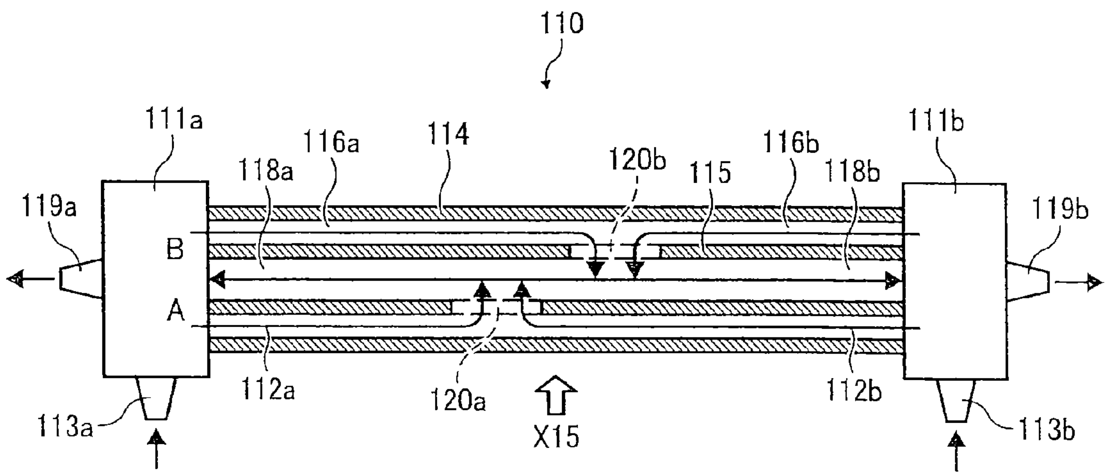


FIG. 35B

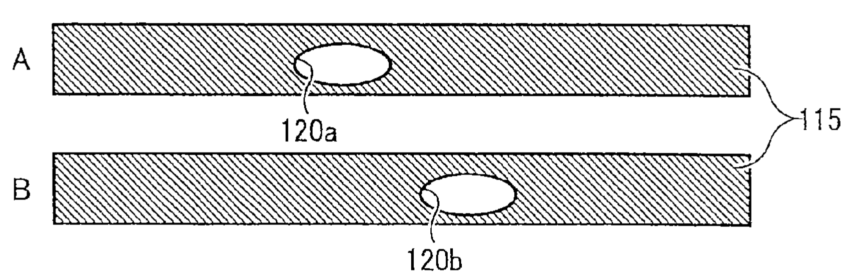


FIG. 36

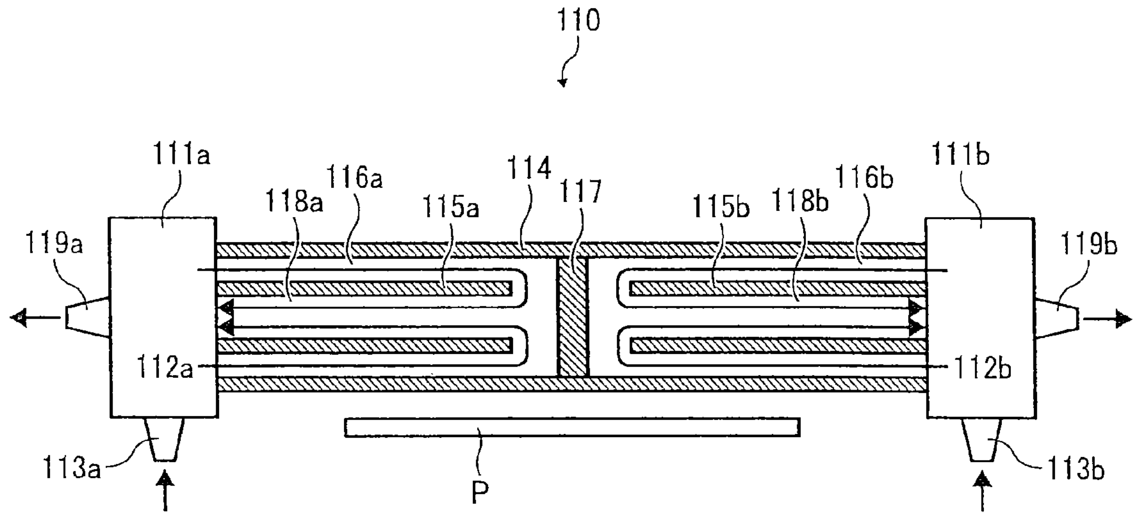

110
111a
116a
114
117
115b
118b
116b
111b
118a
115a
119a
119b
112a
112b
113a
113b
P

FIG. 37

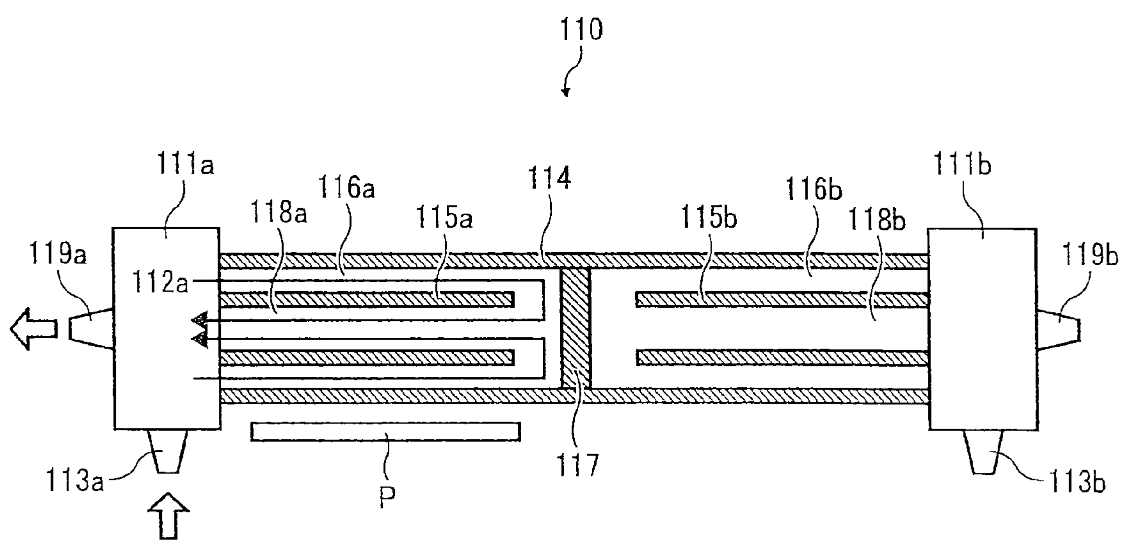

110
111a
116a
114
116b
111b
118a
115a
115b
118b
119a
119b
112a
113a
113b
117
P

FIG. 38

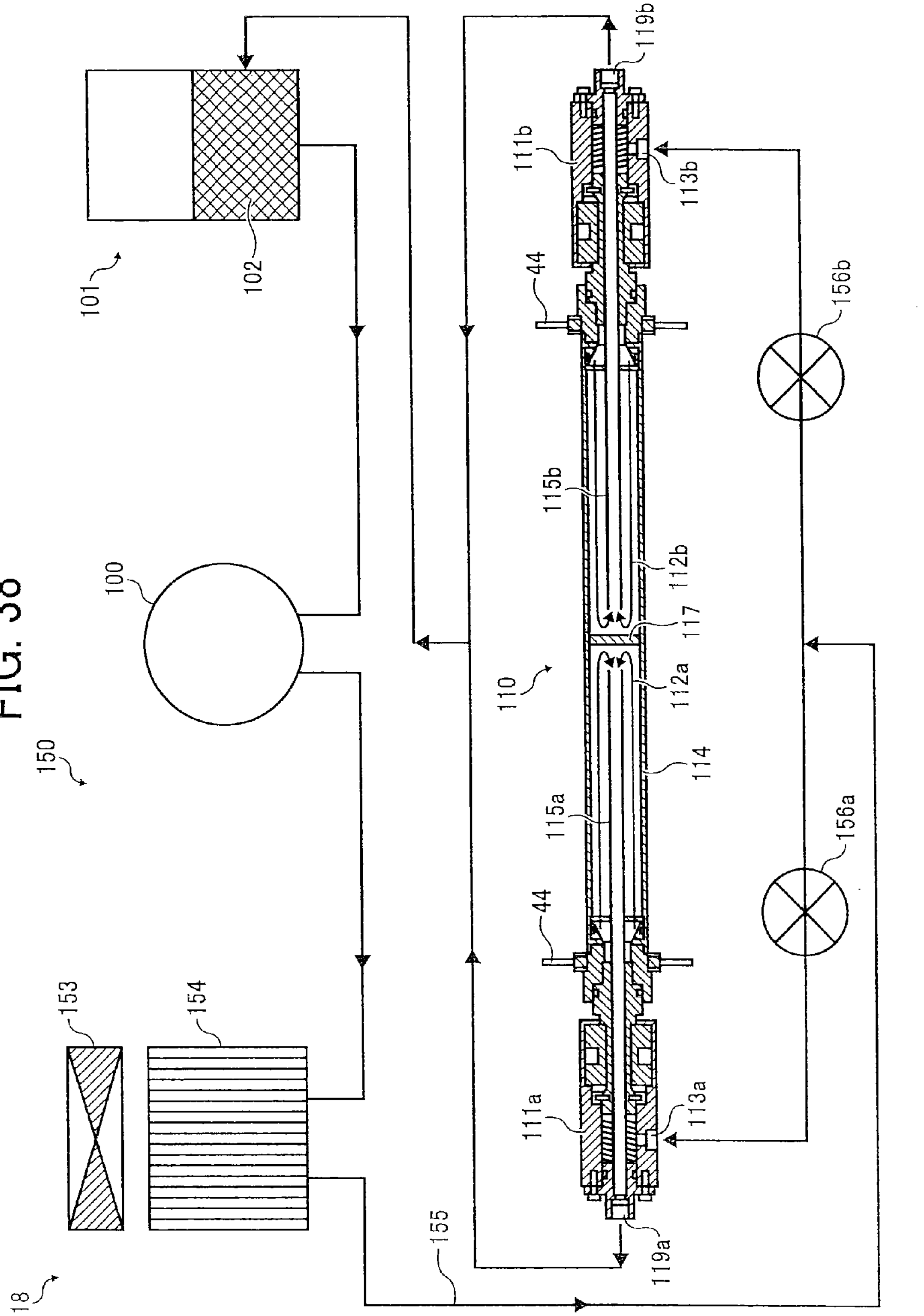
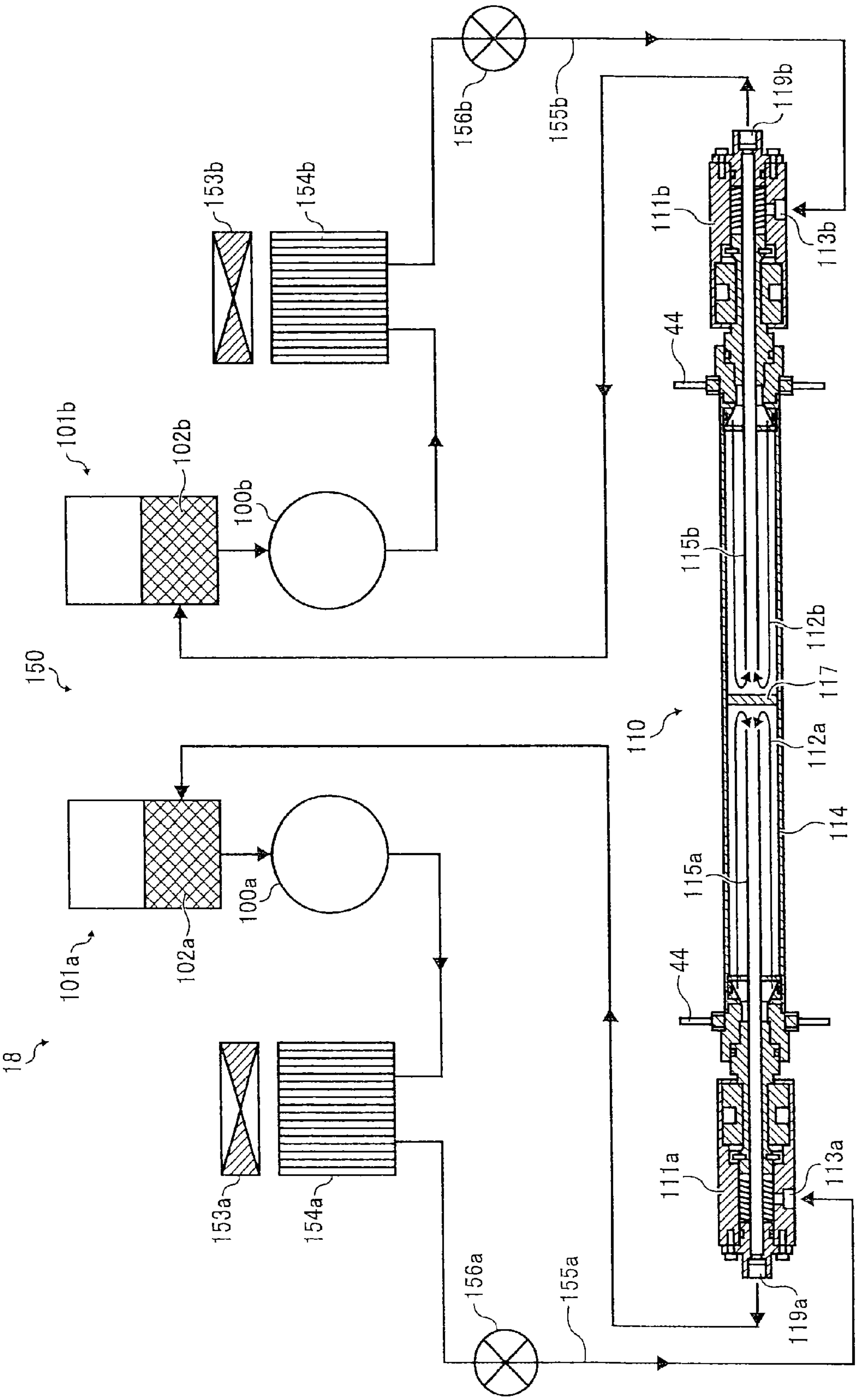
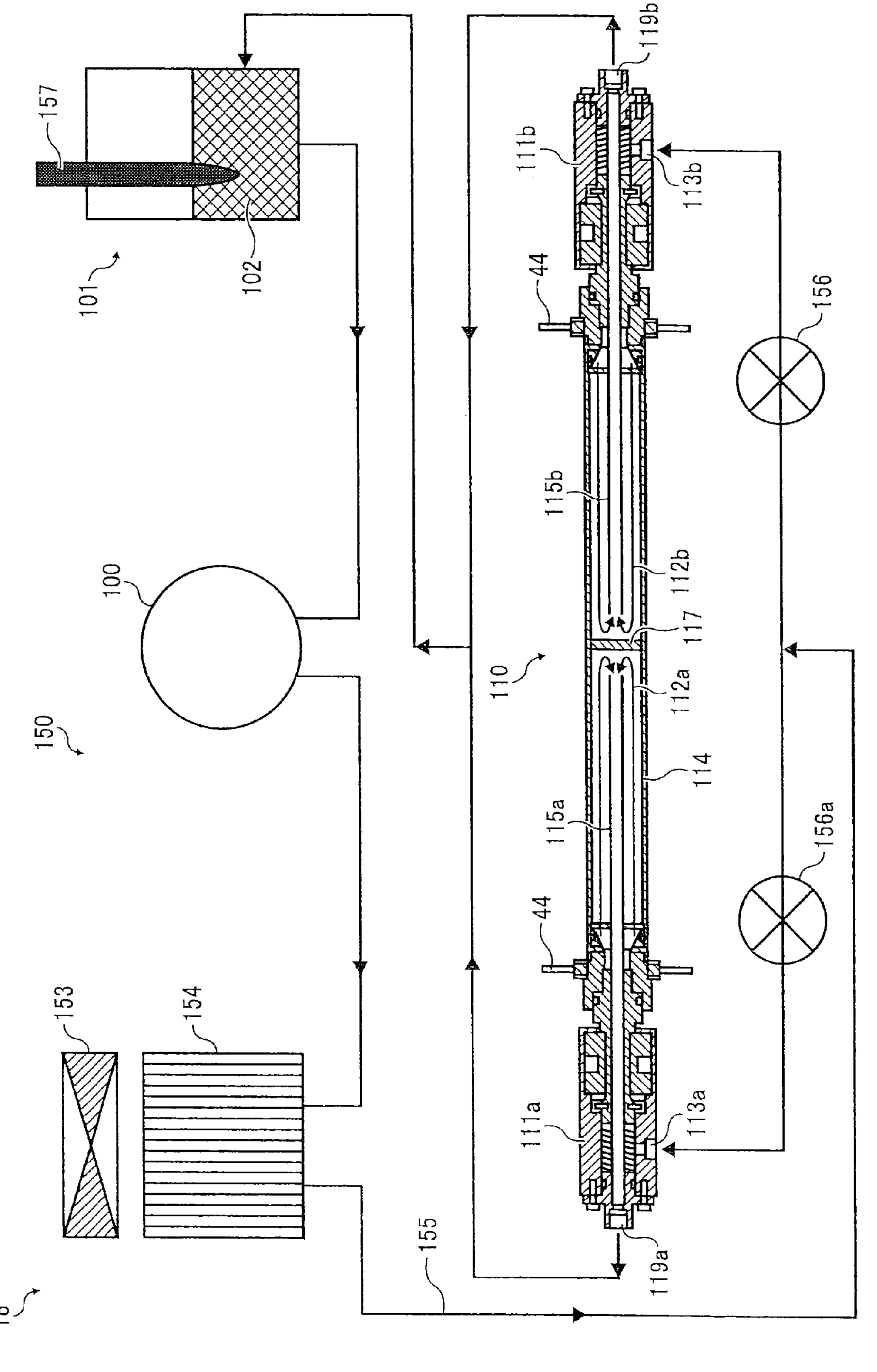

101
102
100
150
153
154
155
18
110
111a
111b
112a
112b
113a
113b
114
115a
115b
117
119a
119b
44
44
156a
156b

FIG. 39


18
150
101a
102a
100a
153a
154a
156a
155a
101b
102b
100b
153b
154b
156b
155b
110
44
44
111a
113a
119a
115a
114
112a
117
112b
115b
111b
113b
119b



18
150
101
102
157
100
153
154
155
110
111a
111b
112a
112b
113a
113b
114
115a
115b
117
119a
119b
44
44
156
156a

FIG. 40

FIG. 41

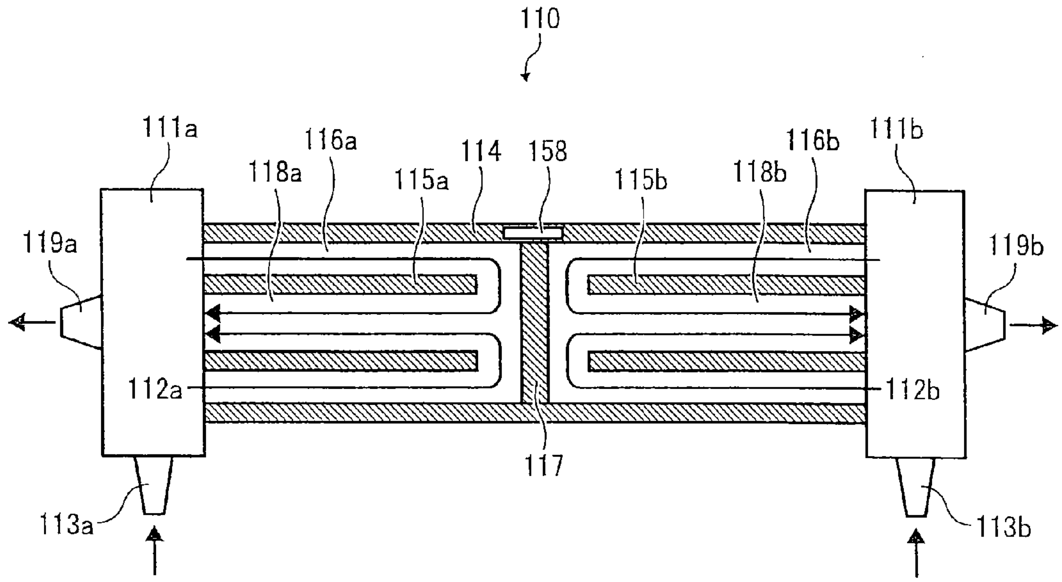

110
111a
116a
114
158
116b
111b
118a
115a
115b
118b
119a
119b
112a
112b
117
113a
113b

FIG. 42

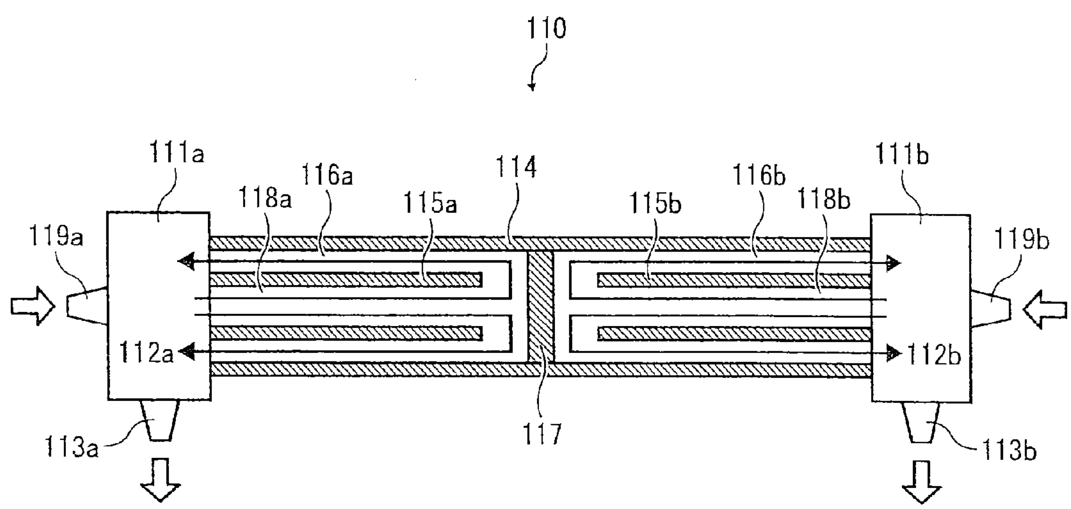

110
111a
116a
114
116b
111b
118a
115a
115b
118b
119a
119b
112a
112b
117
113a
113b

FIG. 43A

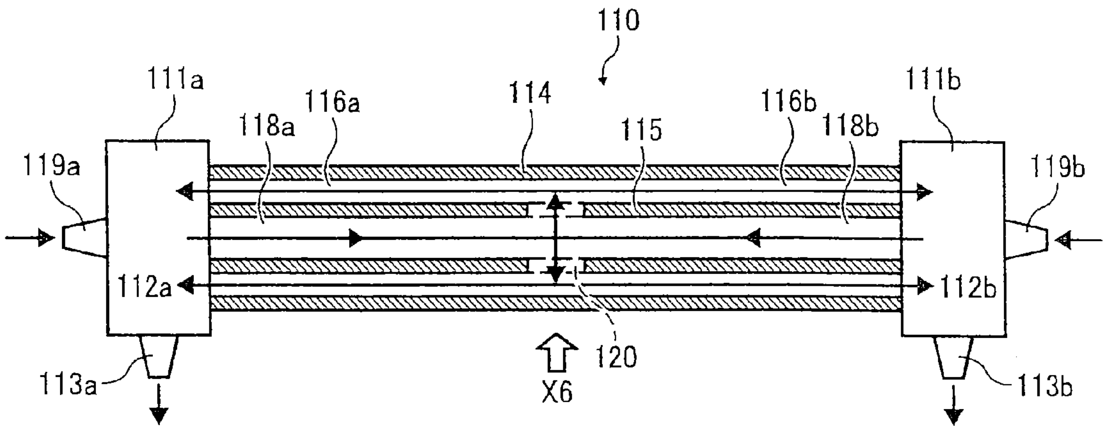


FIG. 43B

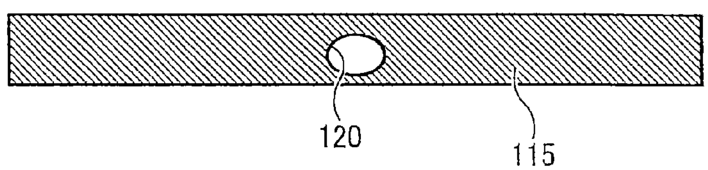


FIG. 44A

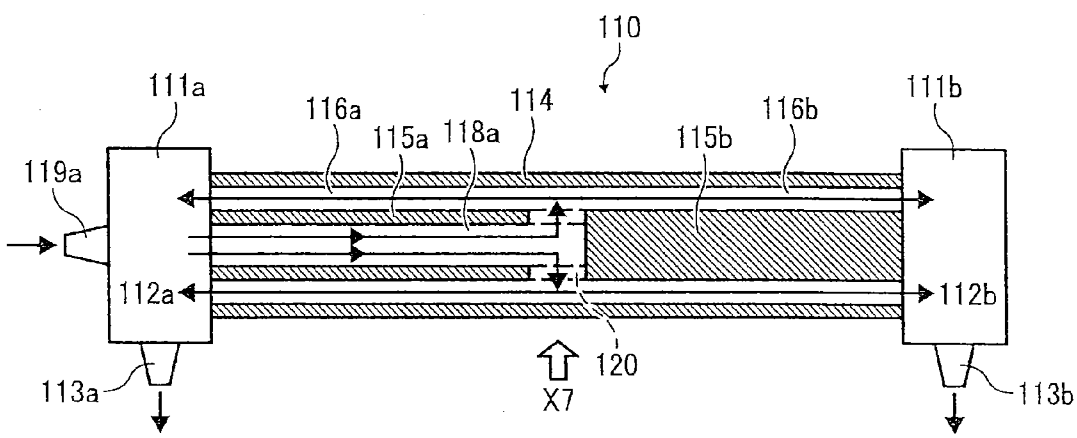


FIG. 44B

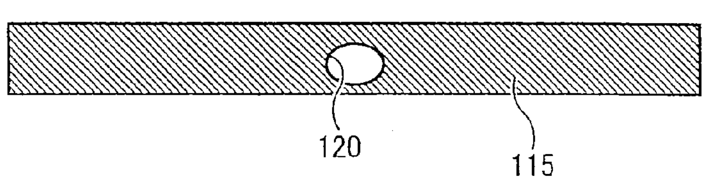


FIG. 45A

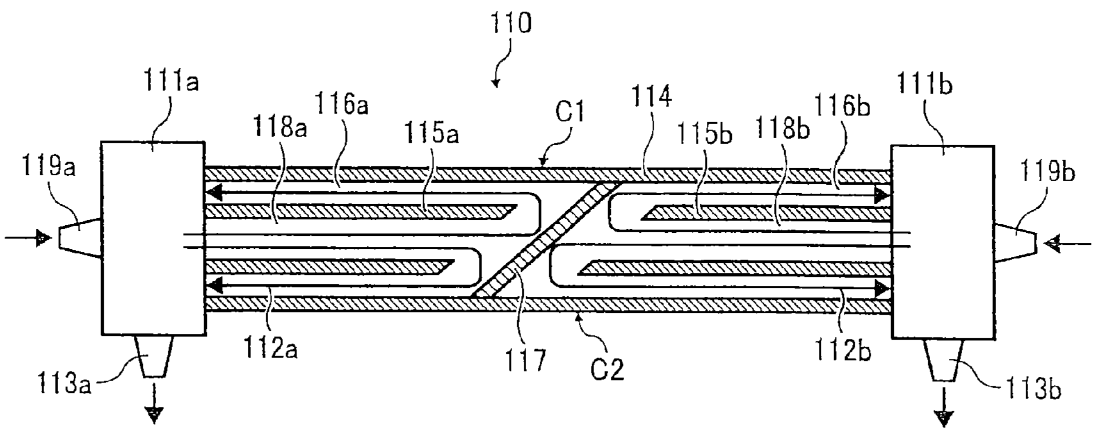


FIG. 45B

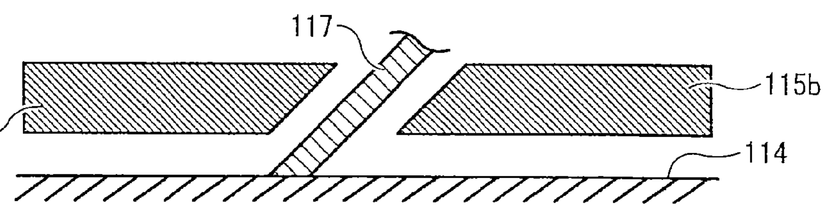


FIG. 46A

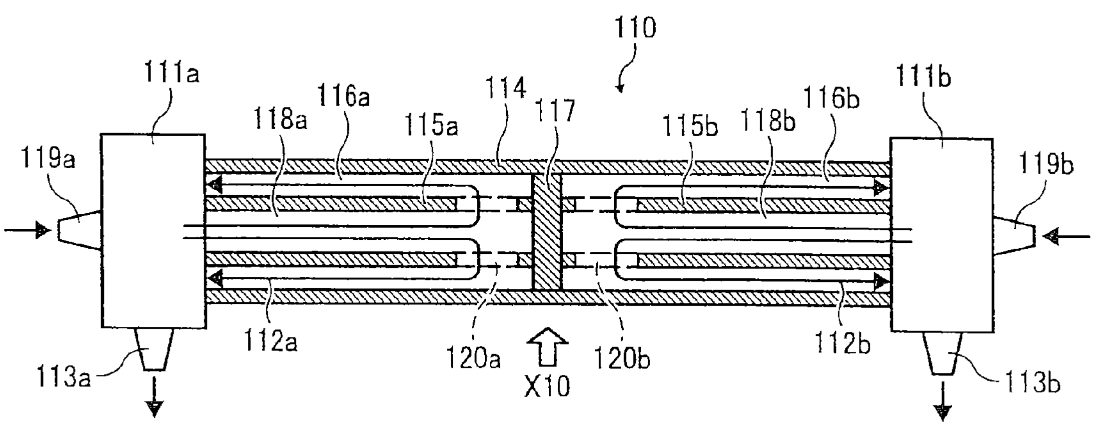


FIG. 46B

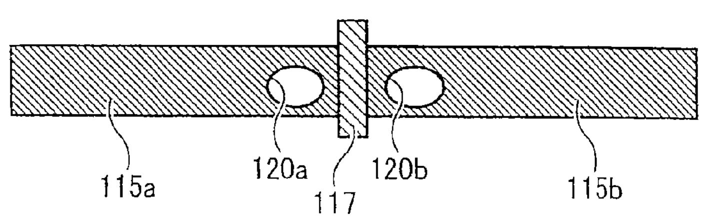


FIG. 47A

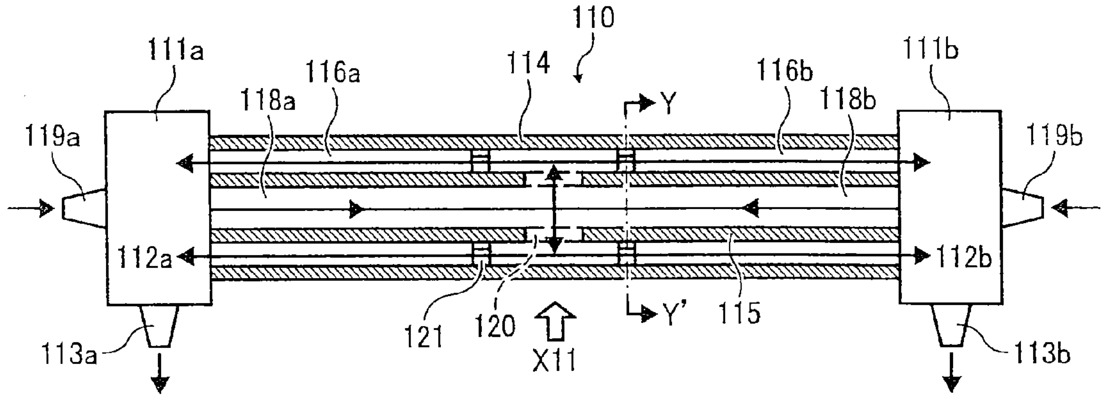


FIG. 47B

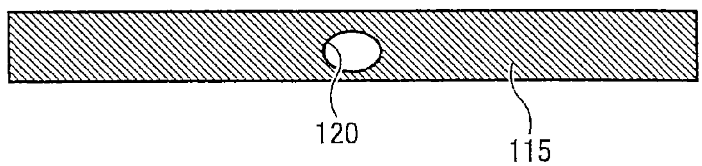


FIG. 48A

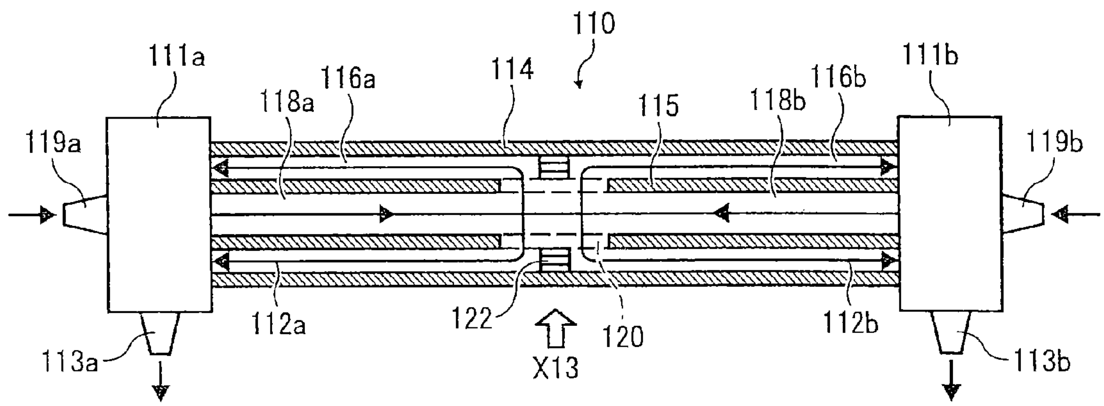


FIG. 48B

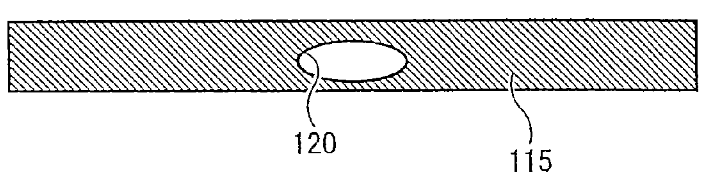


FIG. 49A

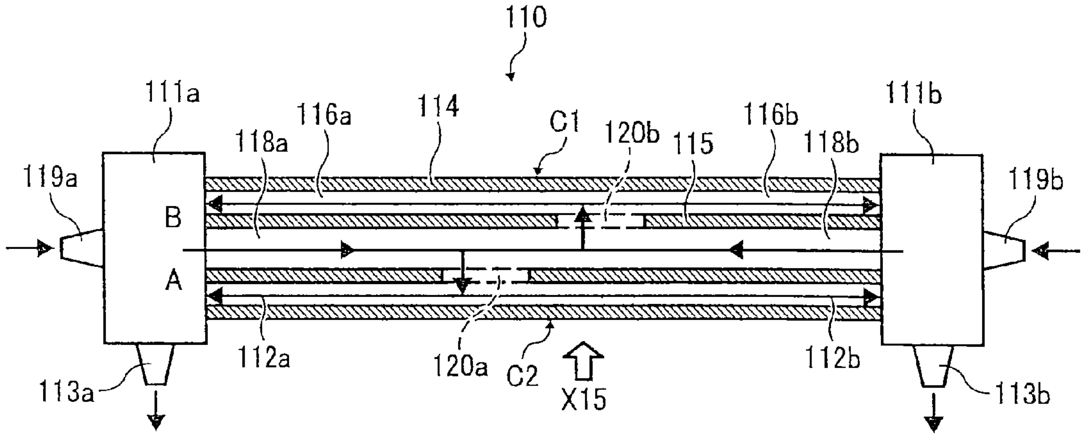


FIG. 49B

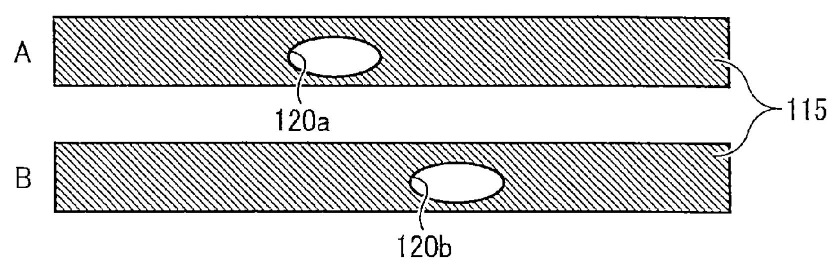


FIG. 50

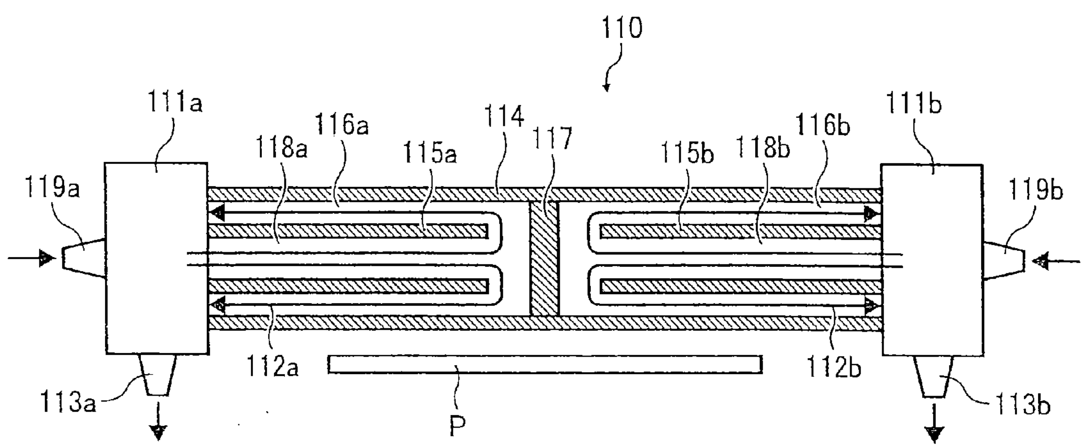
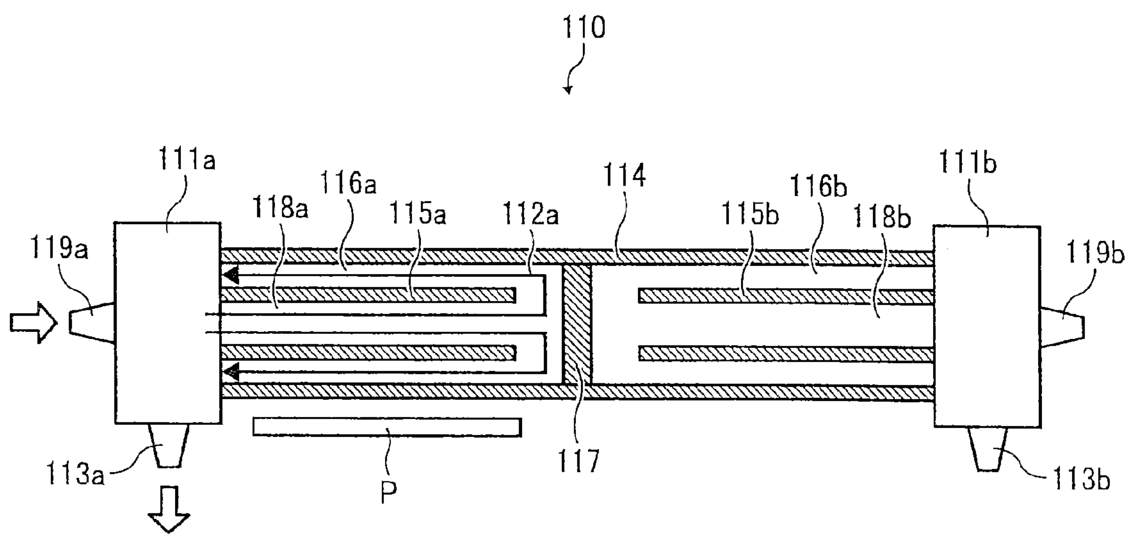
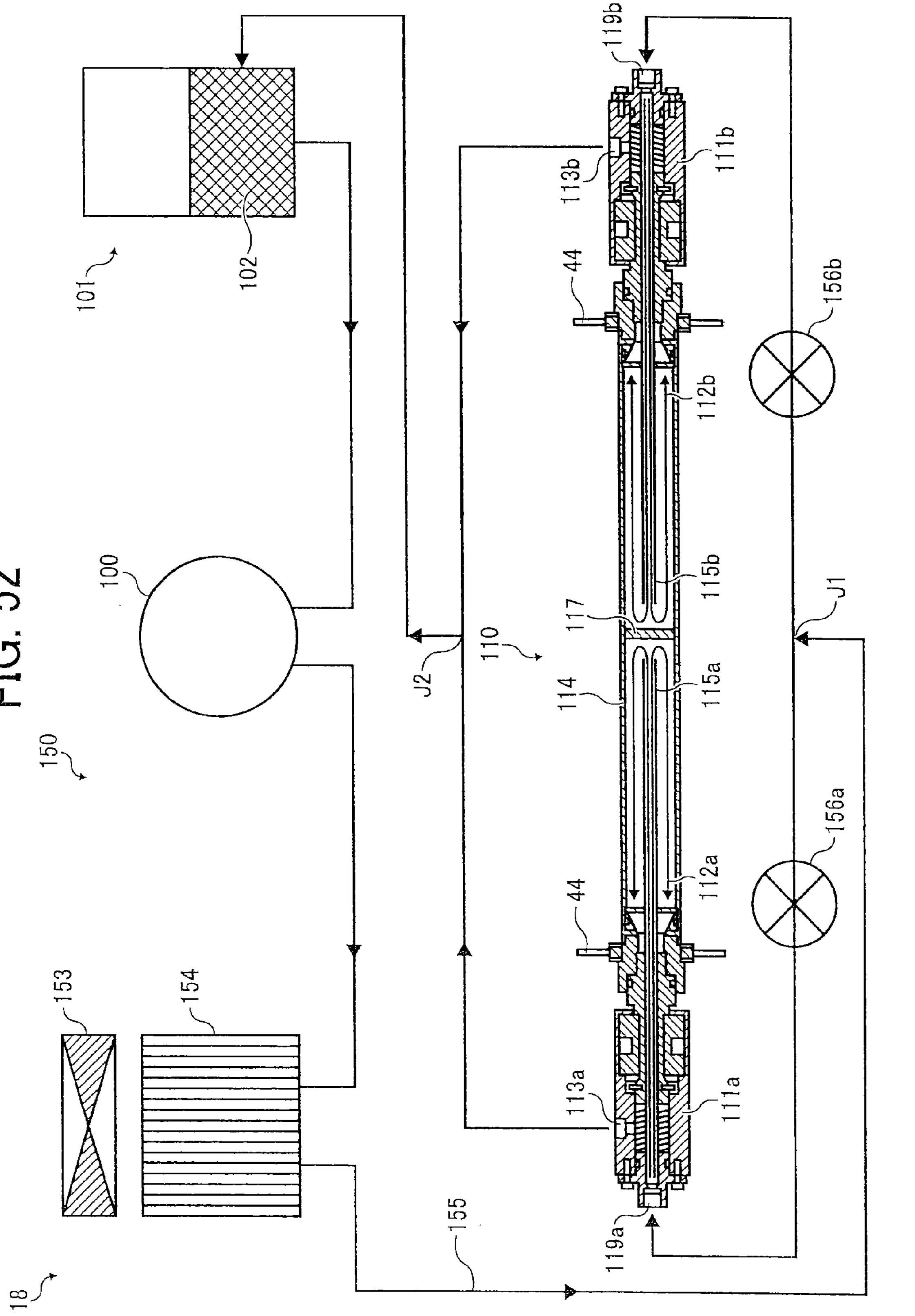


FIG. 51


110
111a
116a
118a
115a
112a
114
115b
116b
118b
111b
119a
119b
113a
117
P
113b



18
150
153
154
100
101
102
155
J2
110
114
117
115a
115b
112a
112b
113a
113b
111a
111b
119a
119b
44
44
156a
156b
J1

FIG. 52

FIG. 53

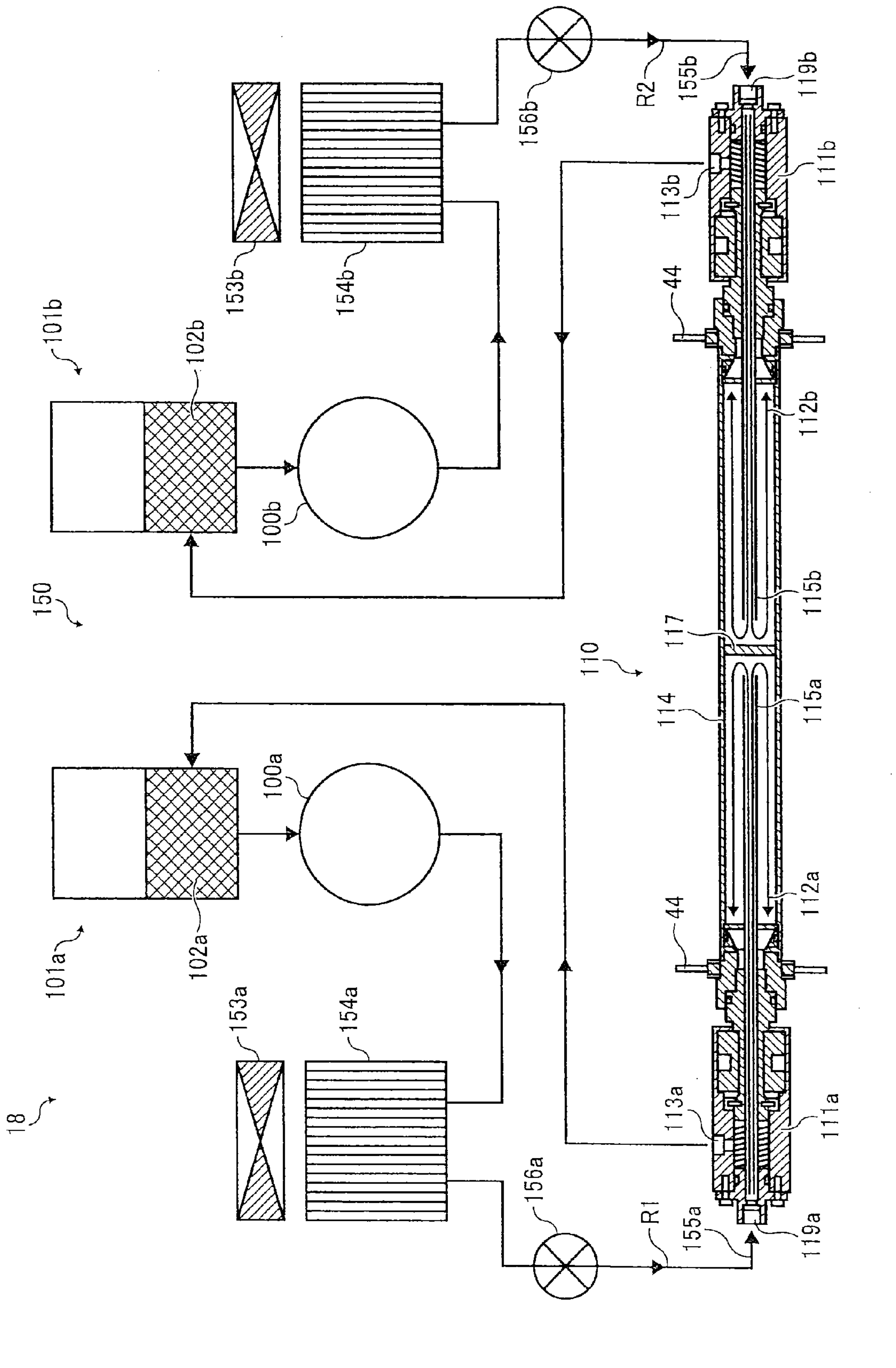

18
150
101a
101b
102a
102b
100a
100b
153a
153b
154a
154b
156a
156b
R1
R2
155a
155b
119a
119b
111a
111b
113a
113b
44
44
112a
112b
114
115a
115b
117
110

FIG. 54

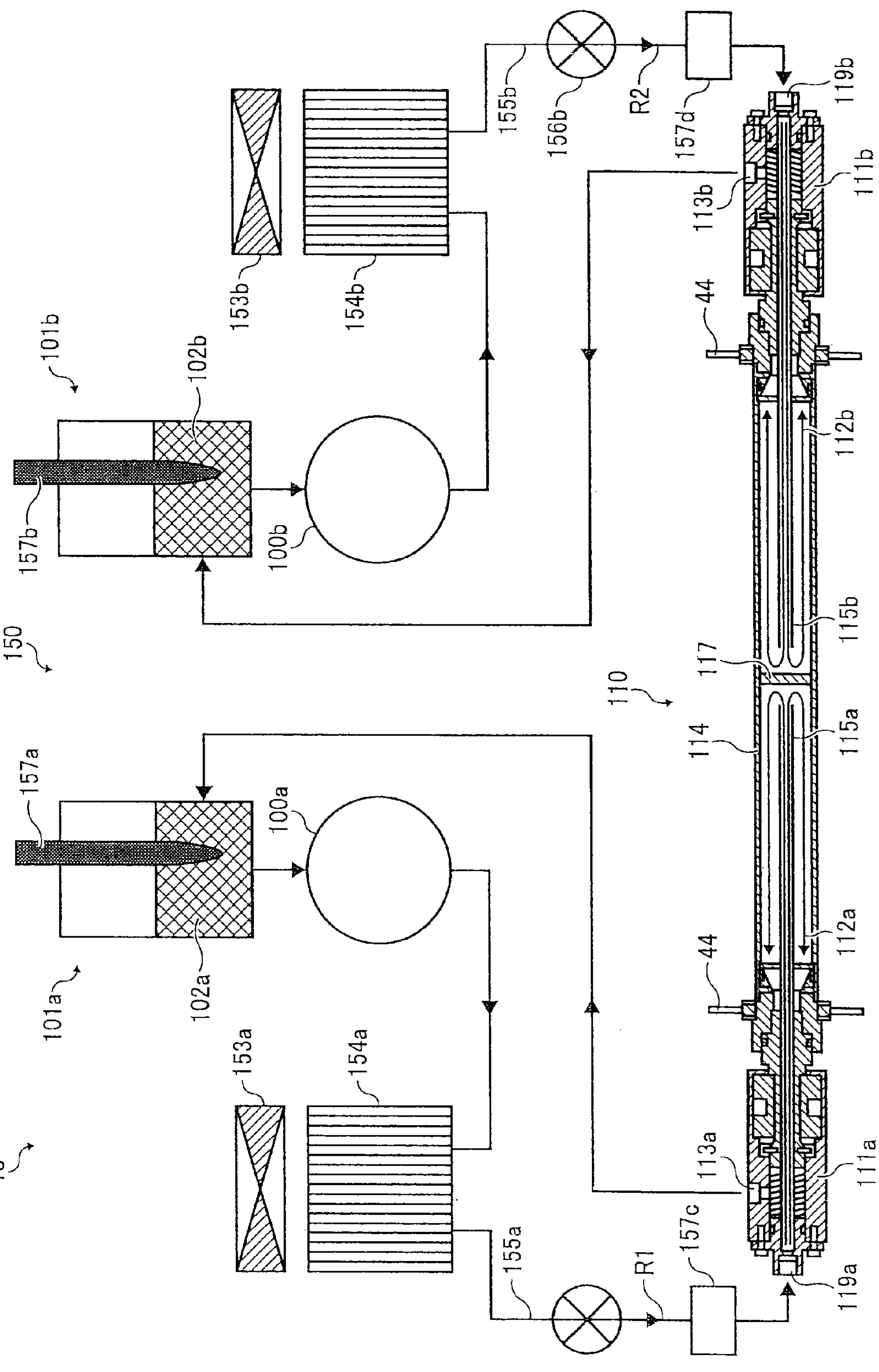
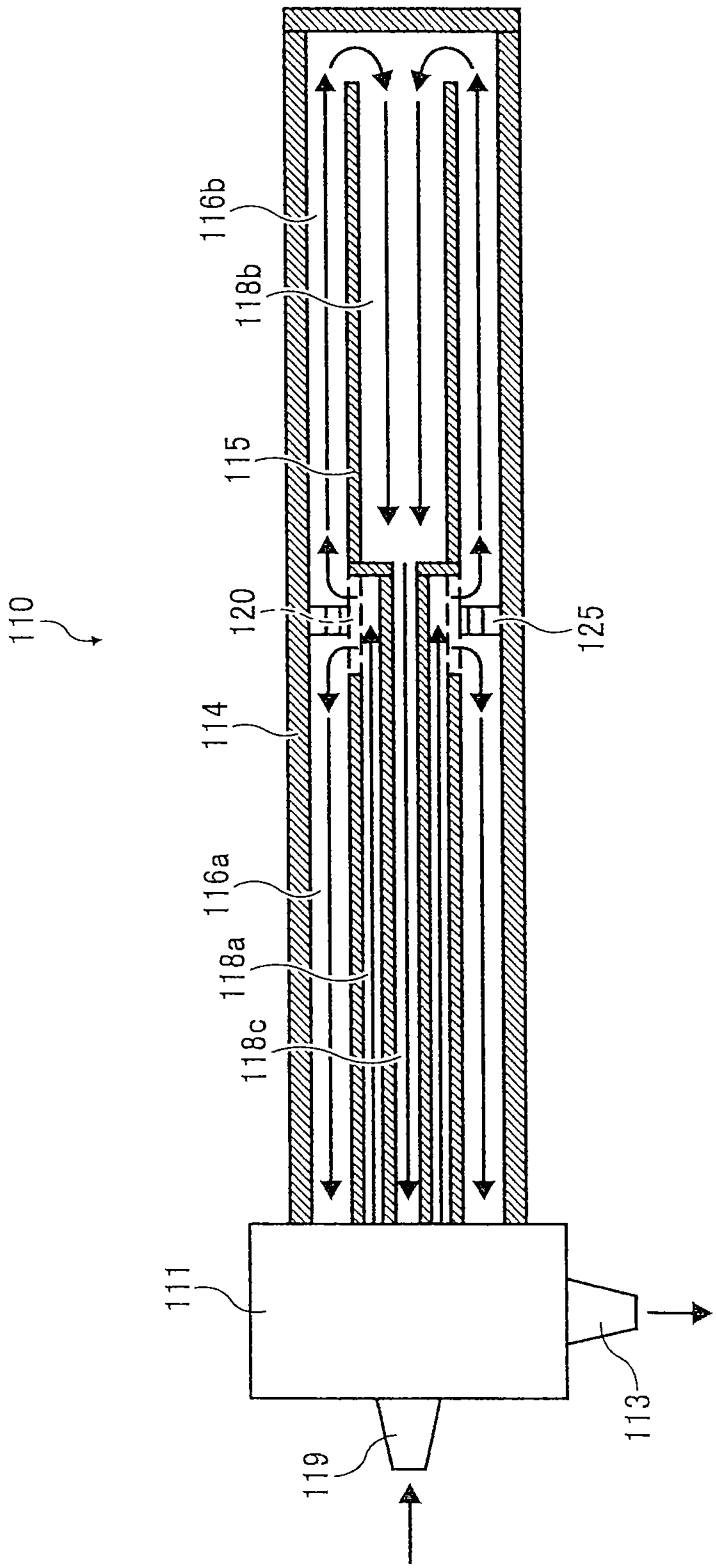

18
150
101a
102a
157a
100a
153a
154a
155a
R1
157c
101b
102b
157b
100b
153b
154b
155b
156b
R2
157d
110
44
44
111a
113a
119a
112a
114
115a
117
115b
112b
111b
113b
119b

FIG. 55



COOLING DEVICE HAVING A TURBULENCE GENERATING UNIT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and is based upon and claims the benefit of priority under 35 U.S.C. §120 for U.S. Ser. No. 12/844,384, filed Jul. 27, 2010, and claims the benefit of priority under 35 U.S.C. §119 from Japanese Patent Application No. 2009-182895, filed Aug. 5, 2009, Japanese Patent Application No. 2009-182899, filed Aug. 5, 2009, and Japanese Patent Application No. 2009-257656, filed Nov. 11, 2009, the entire contents of each of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a cooling device used for an image forming device such as a printer, a facsimile, and a copy machine.

2. Description of the Related Art

Image forming devices that form a toner image on a paper that is a sheet-like member using an electronic photography technique and cause a toner of the toner image to melt and be fused on the paper through a heat fixing device have been known. Generally, the temperature of the heat fixing device depends on a type of a toner or a paper, a paper transport speed, etc. but is set and controlled to a temperature of about 180° C. to 200° C. to quickly fuse the toner. A surface temperature of the paper after passing through the heat fixing device depends on a heat capacity (e.g., specific heat or density) of the paper but has a high temperature of, for example, about 100° C. to 130° C. Since a melting temperature of the toner is comparatively lower, at a point of time directly after passing through the heat fixing device, the toner remains a slightly softened state and is in an adhesive state for a while until the paper is cooled down. Thus, when an image output operation is continuously repeated and papers that passed through the heat fixing device are stacked on a discharged paper receiving unit, if the toner on the paper is not sufficient hardened but in a soft state, the toner on the paper may be attached to another paper, so that a so-called blocking phenomenon may be caused to remarkably degrade the image quality.

In an image forming device disclosed in Japanese Patent Application Laid-open No. 2006-003819, a cooling device with a cooling roller that is rotatably supported to a bracket through a bearing and comes into contact with a paper to cool the paper while transporting the paper is disposed at a down stream side of a heat fixing device in a paper transport direction. The paper that passed through the heat fixing device is cooled down by the cooling roller of the cooling device, so that the toner on the paper is also cooled down and hardened, thereby preventing the occurrence of the blocking phenomenon. The cooling roller has a tubular structure. A cooling liquid flows inside the cooling roller from one end side to the other end side in a longitudinal direction of the cooling roller, and so the cooling roller raised in temperature by depriving heat from the paper is cooled down by the cooling liquid.

In recent years, needs for light printing such as high-speed printing for telephone bills, receipts, etc. or printing of glossy color images on thick papers or coat papers have been increased. In such light printing, since a large amount of printing is performed at a high speed, a high-temperature sheet-like member needs to be cooled down in a shorter time. Unlike printings for office use, since the frequency of color printing is high and many glossy images are present, the fixing unit fixes images on the sheet-like member at a higher temperature, so that high efficiency cooling is required.

However, if the cooling liquid simply flows inside the cooling roller, the temperature of the cooling liquid near an inner wall of the cooling roller is excessively raised, and so it is impossible to effectively cool down the cooling roller by the cooling liquid. As a result, there is a problem in that it is difficult to appropriately cool down the paper through the cooling roller, etc.

Further, in an image forming device disclosed in Japanese Patent Application Laid-open No. 2006-003819, a cooling device with a cooling roller that comes into contact with the paper to cool down the paper while transporting the paper is disposed at a down stream side of a heat fixing device in a paper transport direction. The paper that passed through the heat fixing device is cooled down by the cooling roller of the cooling device, so that the toner on the paper is also cooled down and hardened, thereby preventing the occurrence of the blocking phenomenon. The cooling roller has a tubular structure. A cooling liquid flows inside the cooling roller from one end side to the other end side in a longitudinal direction of the cooling roller, and the cooling roller raised in temperature by depriving heat from the paper is cooled by the cooling liquid.

However, since the cooling liquid flows inside the cooling roller in one direction from one end side to the other end side in the longitudinal direction of the cooling roller through a single path, the temperature of the cooling liquid is lowest at the one end side, and as it is closer to the other end side, the temperature of the cooling liquid is further raised by heat absorbed by the cooling roller from the paper. For this reason, there occurs a problem in that a temperature difference in the longitudinal direction of the cooling roller causes a cooling efficiency difference, etc.

SUMMARY OF THE INVENTION

It is an object of the present invention to at least partially solve the problems in the conventional technology.

According to an aspect of the present invention there is provided a cooling device. The cooling device includes: a cooling roller that comprises a hollow tubular member; a cooling medium transport unit that transports a cooling liquid to the inside of the tubular member; and a turbulence generating unit that is disposed near an inner wall of the tubular member to generate turbulence in the cooling liquid. The cooling device is configured to cause the cooling roller to contact a sheet-like member to cool down the sheet-like member.

According to another aspect of the present invention there is provided a cooling device. The cooling device includes: a cooling roller that contacts a sheet-like member to cool down the sheet-like member; and a cooling medium feeding/retrieving unit that feeds a cooling medium to the inside of the cooling roller from a feed port disposed in the cooling roller and retrieves the cooling medium drained to the outside of the cooling roller from a drain port disposed in the cooling roller. The cooling roller has a dual tube structure in which an inner tube is disposed inside an outer tube and which has an outside flow passage in which the cooling medium flows through a space between the outer tube and the inner tube and an inside flow passage in which the cooling medium flows inside the inner tube, and an opening that causes the outside flow passage to communicate with the inside flow passage is formed in a middle of the inner tube in a longitudinal direction of the cooling roller. A first passage in which the cooling medium fed by the cooling medium feeding/retrieving unit flows through the outside flow passage from one end side to the other end side of the cooling roller and flows into the inside flow passage through the opening and a second passage in which the cooling medium fed by the cooling medium feeding/retrieving unit flows through the outside flow passage from the other end side to the one end side of the cooling roller and flows into the inside flow passage through the opening are formed.

According to still another aspect of the present invention there is provided a cooling device. The cooling device includes: a cooling roller that contacts a sheet-like member to cool down the sheet-like member; and a cooling medium feeding/retrieving unit that feeds the cooling medium to the inside of the cooling roller from a feed port disposed in the cooling roller and retrieves the cooling medium drained to the outside of the cooling roller from a drain port disposed in the cooling roller. The cooling roller has a dual tube structure in which an inner tube is disposed inside an outer tube and which has an outside flow passage in which the cooling medium flows through a space between the outer tube and the inner tube and an inside flow passage in which the cooling medium flows inside the inner tube, and an opening that causes the outside flow passage to communicate with the inside flow passage is formed in a middle of the inner tube in a longitudinal direction of the cooling roller. A first passage in which the cooling medium fed by the cooling medium feeding/retrieving unit flows through the inside flow passage, flows into the outside flow passage through the opening, and flows toward at least one end side of the cooling roller and a second passage in which the cooling medium fed by the cooling medium feeding/retrieving unit flows through the inside flow passage, flows into the outside flow passage through the opening, and flows toward at least the other end side of the cooling roller are formed.

The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a cross-sectional view where a cooling roller of a configuration example 1 according to a first embodiment is cut in an axis direction, and FIG. **1**B is a cross-sectional view when the cooling roller of the configuration example 1 is cut in a diametrical direction;

FIG. **2** is an explanation view illustrating an example of a schematic configuration of a cooling device with a cooling roller that also performs a paper transport function according to the first embodiment;

FIG. **3** is an explanation view illustrating a flow velocity distribution of the inside of the cooling roller according to the first embodiment;

FIG. **4** is a graph illustrating a heat transfer rate distribution at a flow direction downstream side of a separation point in an inner wall of the cooling roller;

FIG. **5**A is an enlarged cross-sectional view illustrating a cooling roller in which an outer tube rotates right and a coil-like member is wound clockwise, FIG. **5**B is an enlarged cross-sectional view illustrating a cooling roller in which an outer tube rotates left and a coil-like member is wound clockwise, FIG. **5**C is an enlarged cross-sectional view illustrating a cooling roller in which an outer tube rotates right and a coil-like member is wound counterclockwise, and FIG. **5**D is an enlarged cross-sectional view illustrating a cooling roller in which an outer tube rotates left and a coil-like member is wound counterclockwise;

FIG. **6** is an explanation view illustrating a configuration of a cooling roller in which a net-like member is disposed as a turbulence generating unit;

FIG. **7** is a cross-sectional view where a cooling roller of a configuration example 2 according to the first embodiment is cut in the axial direction;

FIG. **8**A is a cross-sectional view where a cooling roller of a configuration example 3 according to the first embodiment is cut in the axial direction, and FIG. **8**B is a cross-sectional view where the cooling roller of the configuration example 3 is cut in the diametrical direction;

FIG. **9** is an explanation view illustrating an example in which a coil-like member having a small diameter is disposed inside an outer tube;

FIG. **10** is an explanation view illustrating another example in which a coil-like member having a small diameter is disposed inside an outer tube;

FIG. **11** is an explanation view illustrating a configuration of a cooling roller in which a plurality of coil-like members having a small diameter is disposed near a paper;

FIG. **12** is a view illustrating a case where a vibrating unit for vibrating a coil-like member having a small diameter is disposed;

FIG. **13**A is a cross-sectional view where a cooling roller of a configuration example 5 according to the first embodiment is cut in an axial direction, and FIG. **13**B is a cross-sectional view where the cooling roller of the configuration example 5 is cut in a diametrical direction;

FIG. **14**A is an enlarged cross-sectional view illustrating a cooling roller that includes an outer tube having a coil-like member disposed near an inner wall and a core, and FIG. **14**B is a cross-sectional view illustrating an enlarged configuration in which a coil-like member as a turbulence generating unit is disposed even in a core;

FIG. **15** is a cross-sectional view where a cooling roller in which an outer tube and an inner tube are different in rotation number is cut in the diametrical direction;

FIG. **16** is a cross-sectional view where a cooling roller in which an outer tube and an inner tube are different in rotation number is cut in the axial direction;

FIG. **17**A is an enlarged cross-sectional view illustrating a cooling roller having a tubular structure that includes an outer tube and an inner tube, and FIG. **17**B is an enlarged cross-sectional view illustrating a cooling roller in which a coil-like member as a turbulence generating unit is disposed even in an inner tube;

FIG. **18** is an explanation view illustrating an example in which a coil-like member having a small diameter is disposed in an outer tube;

FIG. **19** is an explanation view illustrating another example in which a coil-like member having a small diameter is disposed in an outer tube;

FIG. **20**A is a cross-sectional view where a cooling roller of a configuration example 6 according to the first embodiment is cut in an axial direction, and FIG. **20**B is a cross-sectional view where the cooling roller of the configuration example 6 is cut in a diametrical direction;

FIG. **21**A is an enlarged cross-sectional view illustrating a cooling roller having a tubular structure that includes an outer tube, an inner tube, and a cylinder, and FIG. **21**B is an enlarged cross-sectional view illustrating a cooling roller in which a coil-like member as a turbulence generating unit is disposed even in a cylinder;

FIG. **22** is an explanation view illustrating a schematic configuration of an image forming device according to the present embodiment;

FIG. **23** is an explanation view illustrating a schematic configuration of a cooling roller of a configuration example 1 according to a second embodiment;

FIG. **24** is a cross-sectional view illustrating a schematic configuration of the cooling roller of the configuration example 1 according to the second embodiment;

FIG. **25** is a cross-sectional view illustrating a schematic configuration of another cooling roller of the configuration example 1 according to the second embodiment;

FIG. **26**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 2 according to the second embodiment, and FIG. **26**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 2;

FIG. **27**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 3 according to the second embodiment, and FIG. **27**B is a cross-sectional view illustrating an enlarged configuration of an inner tube of the cooling roller of the configuration example 3;

FIG. **28** is a cross-sectional view illustrating a schematic configuration of a cooling roller of a modified example of the configuration example 2 according to the second embodiment;

FIG. **29**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 4 according to the second embodiment, and FIG. **29**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 4;

FIG. **30**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 5 according to the second embodiment, and FIG. **30**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 5;

FIG. **31**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 6 according to the second embodiment, and FIG. **31**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 6;

FIG. **32** is a cross-sectional view viewed in the longitudinal direction of the cooling roller of the configuration example 6 according to the second embodiment;

FIG. **33**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 7 according to the second embodiment, and FIG. **33**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 7;

FIG. **34** is a cross-sectional view illustrating a schematic configuration of another cooling roller of the configuration example 7 according to the second embodiment;

FIG. **35**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 8 according to the second embodiment, and FIG. **35**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 8;

FIG. **36** is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 9 according to the second embodiment;

FIG. **37** is an explanation view illustrating a passing position of a paper with respect to a cooling roller according to the second embodiment;

FIG. **38** is a view illustrating a cooling circulation device in which a cooling liquid is fed through one feed unit;

FIG. **39** is a view illustrating a cooling circulation device in which a cooling liquid is fed through two feed units;

FIG. **40** is a schematic view illustrating a cooling circulation device in which a temperature detecting unit for detecting a temperature of a cooling liquid is disposed inside a tank;

FIG. **41** is a view illustrating a schematic configuration of a cooling roller in which a temperature detecting unit for detecting a temperature near a surface of the cooling roller is disposed inside an outer tube;

FIG. **42** is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 1 according to the third embodiment;

FIG. **43**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 2 according to the third embodiment, and FIG. **43**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 2;

FIG. **44**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 3 according to the third embodiment, and FIG. **44**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 3;

FIG. **45**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 4 according to the third embodiment, and FIG. **45**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 4;

FIG. **46**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 5 according to the third embodiment, and FIG. **46**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 5;

FIG. **47**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 6 according to the third embodiment, and FIG. **47**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 6;

FIG. **48**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 7 according to the third embodiment, and FIG. **48**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 7;

FIG. **49**A is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 8 according to the third embodiment, and FIG. **49**B is an enlarged cross-sectional view illustrating an inner tube of the cooling roller of the configuration example 8;

FIG. **50** is a cross-sectional view illustrating a schematic configuration of a cooling roller of a configuration example 9 according to the third embodiment;

FIG. **51** is an explanation view illustrating a passing position of a paper with respect to a cooling roller;

FIG. **52** is a view illustrating a cooling circulation device in which a cooling liquid is fed through one feed unit;

FIG. **53** is a view illustrating a cooling circulation device in which a cooling liquid is fed through two feed units;

FIG. **54** is a view illustrating a cooling circulation device in which a temperature detecting unit for detecting a temperature of a cooling liquid is disposed inside a tank;

FIG. **55** is a cross-sectional view illustrating a schematic configuration of a cooling roller in which a rotating tube joint unit is mounted only to one end side.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, exemplary embodiments of the present invention will be described.

First Embodiment

A cooling roller and a cooling device according to embodiments of the present invention will be described in connection with an image forming device which fixes a toner on a recording paper through a heat fixing unit. However, the cooling roller and the cooling device of the present invention are not limited thereto and can be applied to any device requiring cooling of a sheet medium.

The cooling roller as a cooling unit has a tubular structure and allows the cooling liquid to flow and circulate thereinside to cool down a surface of the cooling roller. The cooling device having the cooling roller is disposed in a paper transport path directly behind a heat fixing unit and comes into contact with the paper while transporting the paper through the cooling roller, thereby removing heat from the paper to cool down the paper.

FIG. **2** is a schematic view illustrating an example of a cooling device **18** having a cooling roller **22** of the present invention which also performs a paper transport function. In the cooling device **18**, a roller **40** and a roller **41** which are disposed apart from each other in a transport direction of a paper P, which is an example of a sheet-like member, (a left-right direction) are provided, and support and extend a transport belt **42** for transporting the paper. The roller **40** at a downstream side in the paper transport direction is used as a driving roller (connected with a driving source (not shown)), and rotates the transport belt **42** in counterclockwise direction to transport the paper from a right side to the left side in the drawing.

A heat fixing unit **16** is disposed at an upstream side of the cooling device **18** in the paper transport direction, and a discharged paper receiving unit **17** is disposed at a downstream side of the cooling device **18** in the paper transport direction. An upper guide **43** that guides the paper P transported from the heat fixing unit **16** is disposed above the roller **41**. A cooling roller **22** downwardly press-contacts the transport belt **42** so as to dig into the transport belt **42** at an intermediate position between the roller **40** and the roller **41**. The cooling roller **22** is rotated so as to rotate together with the transport belt **42** by transport force of the transport belt **42**. A reference numeral **44** in the drawing denotes a bracket that forms a body of the cooling device **18** and fixedly or rotatably supports components such as the roller **40**, the roller **41**, the cooling roller **22**, and the upper guide **43**. The cooling device **18** is constituted as one unit by the bracket **44** and mounted to a body of an image forming device.

The paper P which was heated by the heat fixing unit **16** to become a high temperature passes through the cooling device **18** before being discharged to the discharged paper receiving unit **17**. In detail, the paper P which becomes a high temperature by passing through the heat fixing unit **16** enters between the upper guide **43** and the roller **41** of the cooling device **18**, then passes through a nip area formed by the cooling roller **22** and the transport belt **42**, and is discharged to the discharged paper receiving unit **17**. The inside of the cooling roller **22** has a tubular structure. The cooling liquid sufficiently cooled down in the outside is fed to the inside of the cooling roller **22**, circulated inside the cooling roller **22**, and then drained from the inside of the cooling roller **22**. Since the paper P is passed through while closely contacting the cooling roller **22** in the nip area formed when the cooling roller **22** contacts the transport belt **42**, the heat of the paper P is absorbed into the cooling roller **22**, so that the paper P is sufficiently cooled down. For example, when the surface temperature of the paper P directly after passing through the heat fixing unit **16** is about 100° C., the paper P can be cooled down to about 50° C. to 60° C. by passing the paper P through the cooling device **18**.

As will be explained later, the cooling roller **22** is communicated/connected with a cooling liquid circulation unit including a tank **101**, a pump **100**, a radiator **103** having a cooling fan **104** mounted therein, etc. through a rotating tube joint unit. As the sealed cooling liquid is circulated, the cooling roller **22** is cooled down.

In an image forming device of an electronic photography type, the high-temperature paper to which the toner is fixed may be curled. Further, the toner may not be completely fixed so that the papers in a stacked state stick to each other to remarkably degrade the image quality. Therefore, cooling has been required.

Conventionally, in an image forming device of an electronic photography type for office use, in order to cool down the high-temperature paper, a technique of performing cooling by directly blowing air to the top surface of the paper and the bottom surface of the belt through the cooling fan or a technique of performing cooling by holding the paper by being nipped by the heat pipe roller having an end cooled down by the cooling fan has been frequently employed.

However, in recent years, in an image forming device of an electronic photography type, needs for light printing such as high-speed printing for telephone bills, receipts, etc. or printing of glossy color images on thick papers or coat papers have been increased. In light printing through such an image forming device of an electronic photography type, a large amount of printing is performed at a high speed, and thus the high-temperature paper needs to be cooled down in a shorter time. Unlike printing for office use, since the frequency of color printing is high and glossy images are frequency printed, the fixing unit fixes an image on the paper at a higher temperature. Therefore, there is a demand for higher-efficiency cooling than the conventional method.

For this reason, liquid cooling techniques, having higher cooling efficiency than the cooling fan or the heat pipe roller described above, that passes a circulating cooling liquid through a hollow cooling roller and cools down the high-temperature paper by the cooling roller starts to be suggested.

In order to efficiently decrease the temperature of the paper, it is necessary to increase heat flux from the paper to the cooling liquid across a wall portion of the cooling roller. The heat flux between the wall portion of the cooling roller and the cooling liquid is expressed as in Expression 1 showing convective heat transfer based on "J. P Holman, "Heat Transfer Engineering (First Book), Brain Books, P11 to P12".

$$W=h\cdot A\cdot(Tr-Tw) \tag{1}$$

wherein

W [W]: heat flux

h [W/m^2·° C.]: heat transfer rate of a roller inner wall surface

A [m^2]: roller inner wall area

Tr [° C.]: roller inner wall surface temperature

Tw [° C.]: liquid temperature (at a position sufficiently away from a roller inner wall surface)

In Expression 1, in order to increase the heat flux W, it is necessary to decrease the liquid temperature Tw, increase the roller inner wall area A, or improve the heat transfer rate h of the roller inner wall surface.

In Expression 1, increasing the heat transfer rate or specific heat by changing a fluid that flows inside the roller from air to the cooling liquid or increasing the speed of the fluid inside the roller, in order to increase the heat flux W, corresponds to increasing the heat transfer rate h of the roller inner wall surface. Increasing the fluid speed puts a great burden on a pump that feeds the fluid to the inside of the roller and thus cannot be easily performed.

Further, in Expression 1, the heat flux W can be increased by decreasing the liquid temperature Tw. However, when the cooling fan and the radiator are used as a unit of lowering the liquid temperature Tw, it is essentially impossible to decrease the liquid temperature Tw to a temperature lower than a room temperature. Therefore, the liquid temperature Tw is not lowered as much as expected. Further, when a refrigerating machine is used as a unit of decreasing the liquid temperature Tw, the liquid temperature Tw is lowered to a temperature lower than the room temperature. However, power consumption of the refrigerating machine or the initial investment cost is increased, and it is not easy to implement.

For this reason, in the present embodiment, the occurrence of these problems is prevented, and the cooling efficiency of the paper P by the cooling roller **22** is improved.

Configuration Example 1

FIG. **1**A is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the axis direction, and FIG. **1**B is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the diametrical direction.

In the cooling roller **22** of the present configuration example, a coil-like member **2** as a turbulence generating unit for generating turbulence in a cooling liquid in an outer tube **1** is disposed near an inner wall of the hollow outer tube **1** that forms the cooling roller **22**. An end of the coil-like member **2** in the axial direction (thrust direction) of the cooling roller is fixed by a fixing bar **60** that is a protruding member formed on the inner wall of the outer tube **1**. Each end of the outer tube **1** forms an opening, and a flange **38** is press-fitted into and mounted to the outer tube **1** from the each opening. A shaft of the flange **38** is press-fitted into a bearing **37** disposed inside a rotary joint **35**. A seal member **39** made of resin prevents a liquid from being leaked from between an inner wall of a barrel section **36** of the rotary joint **35** and a shaft of the flange **38** to the outside of the rotary joint **35**.

The paper P is held between the outer tube **1** of the cooling roller **22** and the transport belt **42** (see FIG. **2**) which is not shown. As the outer tube **1** rotates in an arrow direction in FIG. **1**B, the paper P is transported from the right side to the left side in the drawing.

In FIG. **1**A, the cooling liquid that flows from the left side in the drawing to the inside of the outer tube **1** initially forms a flow field similar to a Poiseuille flow such as a flux profile **3** illustrated in FIG. **3** when the liquid is transferred in the outer tube **1**. According to the flux profile **3**, the flow collides with the coil-like member **2** disposed near the inner wall of the outer tube **1** shown in FIG. **1**A or **1**B, and thereby is agitated. As a result, as illustrated in FIG. **3**, the flow is adhered to the inner wall of the outer tube **1** as shown by adhesion **4** or separated from the inner wall of the outer tube **1** as shown by separation **5**.

At a position where the flow is adhered to or separated from, the heat transfer rate from the inner wall of the outer tube **1** to the cooling liquid is improved. In connection with separation of the flow, as illustrated in FIG. **4**, when separation **5** of the cooling liquid flow occurs on the inner wall surface of the outer tube **1**, the heat transfer rate at a position x in a downstream direction of the cooling liquid from a position of separation **5** as an original point is distributed like hx based on Expression 2, which is a convective heat transfer expression when a flow is a laminar flow, stated in "J. P Holman, "Heat Transfer Engineering (First Book), Brain Books, P144 to P160, Expression 5-41". At this time, a theoretical heat transfer rate at a position of separation **5**, that is, the original point, is increased to +∞ (but, there is no actual case where the heat transfer rate technically becomes +∞ at a position where x is zero (0)).

$$hx=0.332k\cdot Pr^{(1/3)}\cdot\sqrt{(U\infty/(\nu\cdot x))} \quad (2)$$

wherein

x [m]: position from a separation point of the flow

hx [W/m^2·K]: local heat transfer rate at a position x

Pr [l]: Prandtl coefficient

U∞ [m/s]: main flux of the flow sufficiently away from the roller inner wall surface

νλ[m^2/s]: Kinematic viscosity (=viscosity/density)

k: Heat transfer rate

The separation or adhesion of the flow frequently occurs near the inner wall of the outer tube **1**, and the heat transfer rate at each position where the separation or adhesion of the flow occurs is increased. Therefore, the high heat transfer rate is realized uniformly over the longitudinal direction of the outer tube **1**, and the heat flux from the roller to the cooling liquid is increased. Eventually, the cooling efficiency of the sheet-like member is significantly improved. Therefore, when the high-temperature paper P is held between and transported by the outer tube **1** of the cooling roller **22** and the transport belt **42** (see FIG. **2**) that is not shown, the heat of the paper P is transferred with high efficiency to the cooling liquid that flows inside the outer tube **1** while passing through a position adjacent the wall section of the outer tube **1**, so that the temperature of the paper P is lowered.

The coil-like member **2** that is the turbulence generating unit is disposed near the inner wall of the outer tube **1** and thus does not greatly disturb the flow of the cooling liquid that flows inside the outer tube **1**. It neither acts as large fluid resistance against the cooling liquid that flows inside the outer tube **1** nor puts a great burden on liquid feeding of a pump (not shown) that feeds the cooling liquid into the outer tube **1**. Therefore, it is possible to perform an operation in which power consumption of the pump is saved.

The coil-like member **2** that is the turbulence generating unit may be made of a member different from the outer tube **1** and may have a diameter slightly smaller than a diameter of the inner wall surface of the outer tube **1**. According to such a configuration, in a process of assembling the cooling roller **22**, the coil-like member **2** can be easily inserted into the outer tube **1**, and the coil-like member **2** can be fixed to the inside of the outer tube **1** naturally by frictional force generated between the inner wall surface of the outer tube **1** and the coil-like member **2**. Thus, it can be easily implemented without any special fixing unit. Further, the coil-like member **2** can be easily removed from the inside of the outer tube **1**. Therefore, the maintainability of the cooling roller **22** can be improved.

Further, the flow direction of the cooling liquid may be reverse to a direction illustrated in FIG. **1**A.

When a helical member or a protrusion is disposed in the outer tube **1**, a winding direction of the helical shape may be selected to cause feeding of the same direction as the flow direction of the cooling liquid in view of the rotation direction of the outer tube **1** in order not to cause a fluid resistance problem.

For example, when the cooling liquid flows from the left side to the right side of the outer tube **1** (the left side is the upstream side in the flow direction of the cooling liquid, and the right side is the downstream side in the flow direction of the cooling liquid) as illustrated in FIG. **1**A, and the outer tube **1** rotates right when viewed in the axial direction from the downstream side, the coil-like member **2** that rotates right together with the outer tube **1** should be wound in a right winding direction that causes feeding of the same direction as the flow direction of the cooling liquid in order to generate the turbulence near the inner wall of the outer tube **1** by the coil-like member **2** not to generate the fluid resistance.

FIG. **5**A is an enlarged cross-sectional view of the cooling roller **22** in which the outer tube **1** rotate right and the coil-like member **2** is wound clockwise. FIG. **5**A is a view in which FIG. **1**A is practically depicted to make it easy to understand the winding direction of the coil-like member **2**. In FIG. **5**A, it is understood that the flow direction of the cooling liquid is identical to the feed direction of the cooling liquid by rotation by the coil-like member **2**.

Similarly, when the cooling liquid flows from the left side to the right side in the drawing and the transport direction of the paper P of FIG. **1**B is a reverse direction (the right direction in the drawing), since the outer tube **1** rotates left when viewed in the axial direction from the cooling liquid flow direction downstream side, the coil-like member **2** at this time should be wound in a left winding direction. FIG. **5**D is an enlarged cross-sectional view of the cooling roller **22** in which the outer tube **1** rotates left and the coil-like member **2** is wound counterclockwise. It is understood that the flow direction of the cooling liquid is identical to the feed direction of the cooling liquid by rotation of the coil-like member **2**.

In this way, according to a configuration in which the flow direction of the cooling liquid flowing inside the outer tube **1** of the cooling roller **22** is identical to the feed direction of the cooling liquid by rotation of the coil-like member **2**, it is possible to reduce the fluid resistance by the coil-like member **2** against the cooling liquid flowing inside the outer tube **1**.

Meanwhile, when a turbulence generating unit disposed on the inner wall (the inner circumferential surface) of the outer tube has a helical shape like the coil-like member **2**, the helical shape may be selected to have a winding direction which causes feeding in a direction reverse to the flow direction of the cooling liquid that flows along near the inner wall of the outer tube **1** according to the rotation direction of the outer tube **1**.

The cooling performance is further improved by generating greater turbulence in the cooling liquid near the inner wall of the outer tube **1** compared with the cooling roller **22** having the configuration illustrated in FIGS. **5**A to **5**D. For this purpose, the coil-like member **2** may be wounded in the winding direction reverse to the winding directions of the configurations illustrated in FIGS. **5**A and **5**D so that feeding in a direction reverse to the flow direction of the cooling liquid is caused. As a result, near the inner wall of the outer tube **1**, force (the flow) by the coil-like member **2** that tends to feed the cooling liquid in the reverse direction collides with the flow of the cooling liquid that is directed to the cooling liquid flow direction downstream side. Therefore, more complicated and random turbulence is generated, and the heat transfer rate from the outer tube **1** to the cooling liquid is significantly improved.

Compared to the configurations illustrated in FIGS. **5**A and **5**D in which the feed direction of the cooling liquid by the coil-like member **2** is identical to the flow direction of the cooling liquid that flows inside the outer tube **1**, configuration examples in which the feed direction of the cooling liquid by the coil-like member **2** is reverse to the flow direction of the cooling liquid that flows inside the outer tube **1** are illustrated in FIGS. **5**B and **5**C.

In FIG. **5**A or **5**C, the cooling liquid flows from the left side to the right side in the drawing, and the outer tube **1** rotates right when viewed in the axial direction at the cooling liquid flow direction downstream side. In this case, in order to make the feed direction of the cooling liquid by the coil-like member **2** identical to the flow direction of the cooling liquid that flows inside the outer tube **1**, the coil-like member should be wound clockwise as illustrated in FIG. **5**A. However, in order to make the feed direction of the cooling liquid by the coil-like member **2** reverse to the flow direction of the cooling liquid that flows inside the outer tube **1**, the coil-like member **2** should be wound counterclockwise as illustrated in FIG. **5**C.

Further, in FIG. **5**B or **5**D, the cooling liquid flows from the left side to the right side in the drawing, but the outer tube **1** rotates left when viewed in the axial direction from the cooling liquid flow direction downstream side. In this case, in order to make the feed direction of the cooling liquid by the coil-like member **2** identical to the flow direction of the cooling liquid that flows inside the outer tube **1**, the coil-like member should be wound counterclockwise as illustrated in FIG. **5**D. However, in order to make the feed direction of the cooling liquid by the coil-like member **2** reverse to the flow direction of the cooling liquid that flows inside the outer tube **1**, the coil-like member **2** should be wound clockwise as illustrated in FIG. **5**B.

Such combination relationships are not limited. For example, when the rotation direction of the outer tube **1** and the winding direction of the coil-like member **2** are maintained "as is" and only the flow direction of the cooling liquid is changed to the opposite direction (the direction from the right side to the left side in the drawing), the flow direction of the cooling liquid is reverse to the feed direction of the cooling liquid by the coil-like member **2** in the configurations illustrated in FIGS. **5**A and **5**D.

Therefore, based on a combination relationship among three factors of the rotation direction of the outer tube **1**, the flow direction of the cooling liquid, and the feed direction of the cooling liquid by the coil-like member **2**, the winding direction of the coil-like member **2** may be determined to cause feeding of the cooling liquid by the coil-like member **2** in a direction identical or reverse to the flow direction of the cooling liquid.

However, since a certain shape size of the turbulence generating unit such as the coil-like member **2** may increase the fluid resistance, attention is required. For example, if the coil-like member **2** has a very small wire diameter, an effect resulting from the turbulence is reduced, but even though the feed direction of the cooling liquid by the coil-like member **2** is reverse to the flow direction of the cooling liquid, the fluid resistance is too small to cause a problem. On the contrary, if the coil-like member **2** has a very large wire diameter, the turbulence effect is increased, but since feeding of the cooling liquid by the coil-like member **2** in a direction reverse to the flow direction of the cooling liquid becomes greater and stronger, the fluid resistance is increased. However, since the shape or size of the turbulence generating unit such as the coil-like member **2** is changed to deal with each case according to specification conditions such as the flow velocity and the flow quantity of the cooling liquid, the width (size) of a space that allows the cooling liquid to flow, and a cooling performance target, the shape or size of the turbulence generating unit cannot be categorically determined. Therefore, in order to obtain the maximum turbulence effect with the minimum fluid resistance, an optimum shape or size (for example, a wire diameter dimension) of the turbulence generating unit has been determined by comparing or confirming through a simulation or an actual experimental evaluation. When the turbulence generating unit has a helical shape like the coil-like member **2**, since a helical pitch interval of the helical shape is a factor for determining a turbulence occurrence frequency or an interval of a position where turbulence is generated, the helical pitch interval also needs to be considered.

As the turbulence generating unit, in addition to the coil-like member **2**, for example, a net-like member **6** illustrated in FIG. **6** may be used. Though not to the extent of the net-like member **6**, a plurality of wire-like members may be inserted into the outer tube **1**. Alternatively, a cylindrical roll of a sheet having a plurality of punch holes or a porous medium having some thickness may be inserted into the outer tube **1**.

Configuration Example 2

FIG. **7** is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the axial direction. In the present configuration example, as illustrated in FIG. **7**, the coil-like member **2** which is the turbulence generating unit is disposed only at a part, which is located near the paper P, of the outer tube **1** as viewed in the axial direction. According to the configuration in which the coil-like member **2** is disposed only near a part, which contacts the high-temperature paper P, of the outer tube **1**, the fluid resistance caused by the coil-like member **2** is not generated against the cooling liquid that flows inside the outer tube **1** of the cooling roller **22** in the other parts inside the outer tube **1** where the coil-like member **2** is not disposed. Thus, a load of the pump is reduced, so that the power consumption is decreased, and durability is also improved. Further, a pump lower by one rank can be used, thereby reducing the cost.

Configuration Example 3

FIG. **8**A is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the axial direction, and FIG. **8**B is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the diametrical direction. In the present configuration example, as illustrated in FIGS. **8**A and **8**B, a coil-like member **70** having a diameter much smaller than a diameter of the outer tube **1** is disposed only at a portion of the outer tube **1** near the paper P.

As illustrated in FIG. **9**, a shaft **63** has one end fixedly supported to an end of a rotary joint **35** and the other end positioned inside the outer tube **1** and is lengthy in the axial direction of the cooling roller. A hole is formed in the axial direction of the cooling roller in a sidewall of a fixing bar **60** that is disposed to be fixed to the other end of a shaft **63**. A long and fine wire **61** is passed through the hole in the axial direction of the cooling roller, and the wire **61** is fixed to the fixing bar **60** by a wire fastener **62**. Even though not shown in FIG. **9**, a opposite side of the cooling roller opposite in the axial direction has the same configuration. The coil-like member **70** is fixed near the inner wall of the outer tube **1** by passing the coil-like member **70** through the wire **61**. Further, the coil-like member **70** is fixed by the fixing bar **60** in the axial direction (the thrust direction) of the cooling roller. Through such a configuration, even though the outer tube **1** rotates, the shaft **63** having one end fixedly supported by the rotary joint **35** does not rotate. Therefore, even though the outer tube **1** rotates, the coil-like member **70** passed through the wire **61** that is tightened between the fixing bars **60** disposed in the shafts **63** is not displaced from a position near the paper P.

Further, as illustrated in FIG. **10**, the fixing bar **60** may be disposed by being swingably hung to the shaft **63** through a bearing **64**. At this time, by providing a weight **65** at an end of the fixing bar **60** at a side opposite to the bearing **64**, the coil-like member **70** can be position near the paper P by own weight of the weight **65**.

As a modified example, in FIG. **11**, a plurality of coil-like members **70** having a small diameter is prepared, and the plurality of coil-like members **70** is disposed only at a portion of the outer tube **1** near the paper P in order to adapt to a case where a contact area between the paper P and the outer tube **1** is large. The plurality of coil-like members **70** is fixed near the inner wall of the outer tube **1** by disposing as many components illustrated in FIG. **9** and FIG. **10** as the number of the coil-like members **70**.

In this way, according to the configuration in which the coil-like member **70** having a diameter smaller than the coil-like member **2** is disposed only near the paper P inside the outer tube **1**, the fluid resistance caused by the coil-like member **70** can be reduced and thus the load of the pump is suppressed, the power consumption is reduced, and the durability is also improved, compared to the case where the coil-like member **2** is disposed. Further, a pump lower by one rank can be used and thus the cost can be reduced.

Further, in order to promote the generation of the turbulence, a configuration of externally vibrating the turbulence generating unit such as the coil-like member may be provided. In FIG. **12**, the generation of the turbulence is promoted such that the coil-like member **70** having a small diameter, as the turbulence generating unit, disposed near the paper P is vibrated in a non-contact manner by an oscillatory wave such as an ultrasonic wave emitted from a vibrating unit **9**.

Configuration Example 4

As illustrated in FIG. **14**A, the cooling roller **22** has a tubular structure configured with the outer tube **1**, in which the coil-like member **2** is provided near the inner wall of the outer tube **1**, and a core **31**, and a narrow space is formed between the outer tube **1** and the core **31**. The cooling liquid flows through the space as a fluid passage. In this case, compared to FIG. **5**A, the flow velocity of the cooling liquid is increased, and the turbulence effect caused near the inner wall of the outer tube **1** by the coil-like member **2** is added. Therefore, the heat transfer rate is further improved by the synergetic effect, and further temperature reduction of the paper P is expected.

FIG. **14**B illustrates that a coil-like member **32** as the turbulence generating unit is disposed even at the core **31** compared to FIG. **14**A. The turbulence is generated even near an outer wall of the core **31** by the coil-like member **32** and combined with the turbulence generated near the inner wall of the outer tube by the coil-like member **2** of the outer tube **1**, so that more complicated and larger turbulence is generated in the space between the outer tube **1** and the core **31**. Therefore, the cooling performance can be improved more than the configuration illustrated in FIG. **13**A.

Further, in the case of the cooling roller **22** of the present configuration example, the outer tube **1** and the core **31** may have different rotation numbers. According to this configuration, a rotation speed component of the cooling liquid near the inner wall of the outer tube **1** is greatly different from that near the outer wall of the core **31**. Therefore, the generation of the turbulence is promoted to further improve the heat transfer rate. If the core **31** is different in rotation number from the outer tube **1**, for example, the core **31** has several times as many rotation numbers as the outer tube **1** or stops and does not rotate, and thus the greater the difference is, the more effects can be obtained. In order to obtain the maximum effect, the core **31** may be rotated in a direction reverse to the rotation direction of the outer tube **1**. In addition, as the flow velocity increases due to the narrow space formed between the outer tube **1** and the core **31**, the heat transfer rate is further improved. Further, when the turbulence generating unit such as the coil-like member **32** is disposed even at the core **31**, the heat transfer rate is further improved.

Configuration Example 5

FIG. **13**A is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the axial direction, and FIG. **13**B is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the diametrical direction.

In the cooling roller **22** of the present configuration, an inner tube **7** is disposed inside the outer tube **1**, and the coil-like member **2** as the turbulence generating unit for agitating the cooling liquid inside the outer tube **1** is disposed near the inner wall of the outer tube **1** in a space between the outer tube **1** and the inner tube **7** in which the cooling liquid flows.

In the present configuration example, as illustrated in FIGS. **13**A and **13**B, the cooling roller **22** has a tubular structure configured with the outer tube **1** and the inner tube **7**, and the cooling liquid flows back and forth inside the cooling roller **22**. That is, it is configured such that the cooling liquid flows in from the left side in the drawing through the space formed between the outer tube **1** and the inner tube **7** as a forward flow passage, is U-turned at a right end of the outer tube **1**, and flows outs toward the left side in the drawing through the inside of the inner tube **7** as a return flow passage. The inflow and outflow passages of the cooling liquid may be reversed, that is, the inside of the inner tube **7** may be used as the forward flow passage, and the space formed between the outer tube **1** and the inner tube **7** may be used as the return flow passage.

In the present configuration example, since the flow passage space of the forward flow passage is narrow, compared to FIG. **5**A, the flow velocity of the cooling liquid near the inner wall of the outer tube is increased, and the turbulence effect caused near the inner wall of the outer tube by the coil-like member **2** is added. Thus, the heat transfer rate from the outer tube **1** to the cooling liquid is improved. Further, when the space is more narrowed by making an external diameter size of the inner tube **7** close to an internal diameter size of the outer tube **1**, the same effect as the core **31** illustrated in FIG. **14**A is disposed is obtained.

Further, in the present configuration example, a joint that is disposed at an end of the cooling roller **22** in the axial direction and has a mechanical seal for the inflow/outflow of the cooling liquid to/from the inside of the outer tube **1** may be disposed only at the left side of the cooling roller **22** in the drawing, that is, only at one end side of the cooling roller **22** in the axial direction. In this case, an empty space is formed at the right side of the cooling roller **22** in the drawing, that is, at the other end side of the cooling roller **22** in the axial direction at which the joint unit is not disposed. The empty space contributes to size reduction of the image forming device. When the cooling roller **22** is mounted to the cooling device **18** or the image forming device, the mounting work of the cooling roller **22** can be easily performed without being restricted by a tube or a pipe of the cooling liquid.

In the cooling roller **22** configured with the outer tube **1** and the inner tube **7**, the outer tube **1** and the inner tube **7** may have different rotation numbers as illustrated in FIG. **15**. According to this configuration, a rotation speed component of the cooling liquid near the internal wall of the outer tube **1** is greatly different from that near the outer wall of the inner tube **7**. Therefore, the generation of the turbulence is promoted to further improve the heat transfer rate. If the core **31** is different in rotation number from the outer tube **1**, for example, the core **31** has several times as many rotation numbers as the outer tube **1** or stops and does not rotate, and thus the greater the difference is, the more effects can be obtained. In order to obtain the maximum effect, the inner tube **7** may rotate in a direction reverse to the rotation direction of the outer tube **1**.

For example, as illustrated in FIG. **16**, a magnet **81** is mounted to a rotation shaft of a motor **80** disposed outside a rotary joint, and a magnet **82** is mounted to an outer circumferential surface of the inner tube **7** facing the magnet **81** mounted to the motor **80**. As the magnet **81** mounted to the motor **80** rotates, magnetic force working between both magnets applies rotary force to the magnet **82** mounted to the inner tube **7**, so that the inner tube **7** rotates. In this configuration, the outer tube **1** and the inner tube **7** can have different rotation numbers or different rotation directions from each other by controlling the rotation number or the rotation direction of the motor **80**.

FIG. **17**B illustrates that a coil-like member **33** as the turbulence generating unit is disposed even at the inner tube **7** compared to FIG. **17**A. The turbulence is generated even near the outer wall of the inner tube **7** by the coil-like member **33** and combined with the turbulence generated near the inner wall of the outer tube by the coil-like member **2** of the outer tube **1**. As a result, more complicated and larger turbulence is generated in the space formed between the outer tube **1** and the inner tube **7**, whereby the cooling performance can be further improved.

Further, as illustrated in FIGS. **18** and **19**, a configuration in which the coil-like member **70** having a diameter much smaller than a diameter of the outer tube **1** is disposed only at a portion of the outer tube **1** near the paper P may be employed.

As illustrated in FIG. **18**, the shaft **63** has an one end fixedly supported to the rotary joint **35** and the other end positioned inside the outer tube **1** and is lengthy in the axial direction of the cooling roller. A hole is formed in the axial direction of the cooling roller in a sidewall of the fixing bar **60** that is disposed to be fixed to the other end of the shaft **63**. A long and fine wire **61** is passed through the hole in the axial direction of the cooling roller, and the wire **61** is fixed to the fixing bar **60** by the wire fastener **62**. The coil-like member **70** is fixed near the inner wall of the outer tube **1** by passing the coil-like member **70** through the wire **61**. Further, after the coil-like member **70** is passed through the wire **61**, an end of the wire **61** at a side opposite to the fixing bar **60** is bent, so that the coil-like member **70** does not slip out of the wire **61**. Since the weight of the coil-like member **70** is not so much heavy, the strength of the shaft **63** is sufficient to be supported even though the shaft **63** has a cantilever structure, but in order to increase the strength, two or more shafts **63** may be disposed.

Further, as illustrated in FIG. **19**, the fixing bar **60** may be disposed to be swingably hung to the inner tube **7** through the bearing **64**. In this case, the weight **65** is disposed at an end of the fixing bar **60** at a side opposite to the bearing **64**, so that the coil-like member **70** can be positioned near the paper P by own weight of the weight **65**.

In this way, since the coil-like member **70** having a diameter smaller than the coil-like member **2** is disposed only in a portion of the outer tube **1** near the paper P, the fluid resistance caused by the coil-like member **70** can be reduced more than when the coil-like member **2** is disposed. Therefore, the load of the pump is reduced, the power consumption is reduced, and the durability is also, improved. Further, a pump lower by one rank can be used, and the cost can be reduced.

Configuration Example 6

FIG. **20**A is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the axial direction, and FIG. **20**B is a cross-sectional view where the cooling roller **22** of the present configuration example is cut in the diametrical direction.

The cooling roller **22** of the present configuration example is configured such that the inner tube **7** is disposed inside the outer tube **1**, a hollow cylinder **8** is inserted to the outside of the inner tube **7**, and the cooling liquid flows in a narrow space formed between the outer tube **1** and the cylinder **8** and inside the inner tube **7**. That is, the cooling liquid flows in through the narrow space formed between the outer tube **1** and the cylinder **8** from the left side in the drawing, and the cooling liquid that reaches the right end of the outer tube **1** is U-turned and flows out toward the left side in the drawing through the inside of the inner tube **7**. As the cylinder **8** is disposed as in the present configuration example, the flow velocity near the inner wall of the outer tube **1** is increased compared to when the cylinder **8** is not disposed, and thus the heat transfer rate from the wall of the outer tube **1** to the cooling liquid is improved. As a result, further temperature reduction of the paper P can be obtained. Further, the inflow and outflow passages of the cooling liquid may be reversed, that is, the inside of the inner tube **7** may be used as the forward flow passage, and the space formed between the outer tube **1** and the cylinder **8** may be used as the return flow passage.

In the case of the cooling roller **22**, since the narrow space is formed between the outer tube **1** and the cylinder **8** and the cooling liquid flows through the narrow space as the flow passage, the flow velocity of the cooling liquid is increased compared to FIG. **5**A. Further, since the effect of the turbulence generated near the inner wall of the outer tube by the coil-like member **2** is added, the heat transfer rate from the outer tube **1** to the cooling liquid is further improved, and further temperature reduction of the paper P is expected.

Even in this configuration, the joint unit for the inflow and outflow of the cooling liquid may be disposed only in an end of the cooling roller **22** at the left side in the drawing, it is possible to reduce the size of the image forming device and improve assembling workability. That is, the cooling roller **22** of FIG. **21**A has a configuration in which configurations illustrated in FIGS. **13**A and **17**A are combined and that has the advantages and effects of both configurations.

FIG. **21**B illustrates that a coil-like member **34** as the turbulence generating unit is disposed even at the cylinder **8** compared to FIG. **21**A. The turbulence is generated even near the outer wall of the cylinder **8** by the coil-like member **34** and combined with the turbulence generated by the coil-like member **2** of the outer tube **1**. As a result, more complicated and larger turbulence is generated in the space formed between the outer tube **1** and the cylinder **8**, and thus the cooling performance can be further improved. That is, the cooling roller **22** of FIG. **21**B has a configuration in which configurations illustrated in FIGS. **13**B and **20**B are combined and that has the advantages and effects of both configurations.

Further, in the case of the cooling roller **22** of the present configuration example, the outer tube **1** and the cylinder **8** may have different rotation numbers. According to this configuration, a rotation speed component of the cooling liquid near the inner wall of the outer tube **1** is greatly different from that near the outer wall of the cylinder **8**. Therefore, the generation of the turbulence is promoted to further improve the heat transfer rate. If the cylinder **8** is different in rotation number from the outer tube **1**, for example, the cylinder **8** has several times as many rotation numbers as the outer tube **1** or stops and does not rotate, and thus the greater the difference is, the more effects can be obtained. In order to obtain the maximum effect, the cylinder **88** may be rotated in a direction reverse to the rotation direction of the outer tube **1**. In addition, as the flow velocity increases due to the narrow space formed between the outer tube **1** and the cylinder **8**, the heat transfer rate is further improved. Further, when the turbulence generating unit such as the coil-like member **32** is disposed even at the cylinder **8**, the heat transfer rate of the cooling roller **22** is further improved.

Next, a schematic configuration diagram of a color image forming device of a tandem type and an intermediate transfer belt technique in which the cooling device **18** having the cooling roller **22** of the present invention is mounted is illustrated in FIG. **22**.

An intermediate transfer belt **51** as an intermediate transfer medium is tightened around a plurality of rollers. The intermediate transfer belt **51** is configured to be rotated by the rollers, and process units for image formation are disposed around the intermediate transfer belt **51**.

As the process units for image formation, a first image station **54**Y, a second image station **54**C, a third image station **54**M, a fourth image station **54**Bk are disposed between a roller **52** and a roller **53** above the intermediate transfer belt **51** in an order from an upstream side of the intermediate transfer belt **51** in the rotation direction when a rotation direction of the intermediate transfer belt **51** is a direction indicated by an arrow “a” in the drawing. For example, as the first image station **54**Y, a charging unit **10**Y, an optical writing unit **12**Y, a developing device **13**Y, and a cleaning unit **14**Y are disposed around a drum-shaped photoreceptor **11**Y. A primary transfer roller **15**Y as a transfer unit for the intermediate transfer belt **51** is disposed at a position facing the photoreceptor **11** with the intermediate transfer belt **51** interposed therebetween. The other three image stations have the same configuration. The four image stations are disposed at a predetermined pitch interval in a left-right direction.

In the present embodiment, the optical writing unit **12** is configured with an optical system having a light emitting diode (LED) as a light source but may be configured with a laser optical system having a laser as a light source. The optical writing unit **12** performs light exposure on the photoreceptor **11** based on image information.

Below the intermediate transfer belt **51**, disposed are a paper receiving unit **19** of the paper P that is the sheet-like member, a paper feed roller **23**, a pair of resist rollers **21**, a secondary transfer roller **56**, as a transfer unit from the intermediate transfer belt **51** to the paper P, which is disposed to face a roller **55**, which tightens the intermediate transfer belt **51**, via the intermediate transfer belt **51**, a cleaning unit **59** that is disposed at a position facing a roller **58** contacting a back side of the intermediate transfer belt **51** to contact a front surface of the intermediate transfer belt **51**, a heat fixing unit **16**, the cooling device **18** having the cooling roller **22** for cooling the paper P, and a discharged paper receiving unit **17** that is a discharge section of the paper P on which the toner is fixed. A paper transport path **28** extends from the paper receiving unit **19** to the discharged paper receiving unit **17**. At the time of two-sided image formation, in order to perform image formation on a back side, a paper transport path **29** for two-sided image formation in which the paper P passing through the cooling device **18** once is inverted and transported to a pair of resist rollers **21** again is also provided.

The cooling roller **22** of the cooling device **18** is a heat receiving unit that receives heat of the paper P. The cooling roller **22** is communicated or connected with a radiator **103** having a cooling fan **104**, a pump **100**, and a tank **101** through a pipe **105** and encloses the cooling liquid therein. The cooling liquid is circulated along a circulation passage configured such that the cooling liquid cooled down by the radiator **103** is fed to the cooling roller **22**, drained after traveling inside the cooling roller **22**, then fed to the tank **101** and the pump **100**, and returned to the radiator **103** again as indicated by an arrow at the pipe **105**. The cooling liquid is circulated by rotation pressure of the pump **100**, and releases heat at the radiator **103**, so that the cooling liquid is cooled down and thus the cooling roller **22** is also cooled down. Power of the pump **100** or the size of the radiator **103** is selected based on a flow quantity, pressure, and cooling efficiency which are determined according to a heat design condition (a condition of a heat quantity and a temperature that should be cooled down by the cooling roller **22**).

An image forming process will be explained in connection with the first image station **54**Y. The image forming process is based on a general electrostatic recording technique. Light exposure is performed by the optical writing unit **12**Y to form an electrostatic latent image on the photoreceptor **11**Y uniformly charged in the dark by the charging unit **10**Y. The electrostatic latent image is converted to a toner image that is a visible image by the developing device **13**Y. The toner image is transferred from the photoreceptor **11**Y to the intermediate transfer belt **51** by the primary transfer roller **15**Y. After transfer, a surface of the photoreceptor **11**Y is cleaned by the cleaning unit **14**. The other image stations **54** have the same configuration as the first image station **54**Y and perform the same image forming process.

Developing devices **13** in the image stations **54**Y, **54**C, **54**M, and **54**Bk have functions of forming visible images by toners of four different colors. If the image stations **54**Y, **54**C, **54**M, and **54**Bk are assigned yellow, cyan, magenta, and black, respectively, it is possible to form a full color image. Therefore, while a same image formation area of the intermediate transfer belt **51** pass through the four image stations **54**Y, **54**C, **54**M, and **54**Bk in order, the toner images are superposed by being transferred onto the intermediate transfer belt **51** by one color by a transfer bias applied by the primary transfer rollers **15** each of which is disposed to face each photoreceptor **11** with the intermediate transfer belt **51** interposed therebetween. Thereby, at a point of time when the same image formation area passed through the image stations **54**Y, **54**C, **54**M, and **54**Bk once, a full color toner image can be formed on the same image area by the superposed transfer.

The full color toner image formed on the intermediate transfer belt **51** is transferred onto the paper P. After the transfer, the intermediate transfer belt **51** is cleaned by the cleaning unit **59**. The transfer onto the paper P is performed by applying a transfer bias at the time of transfer on the roller **55** to the secondary transfer roller **56** through the intermediate transfer belt **51** and passing the paper P through a nip section between the secondary transfer roller **56** and the intermediate transfer belt **51**. After the transfer onto the paper P, the full color image supported on the paper P is fixed by the heat fixing unit **16**, so that a final full color image is formed on the paper P, and then the paper P is stacked on the discharged paper receiving unit **17**.

In the image forming device of the present embodiment, before the paper P is stacked on the discharged paper receiving unit **17**, the paper P passes through the cooling device **18** disposed directly behind the heat fixing unit **16**. At this time, the paper P heated by the heat fixing unit **16** passes through while contacting the cooling roller **22** that is the heat receiving unit. The surface of the cooling roller **22** then absorbs heat from the paper P and transfers the heat to the cooling liquid inside the cooling roller **22**. The cooling liquid that became a high temperature by the transferred heat is thereafter drained from the cooling roller **22** and fed to the radiator **103** having the cooling fan **104** mounted therein via the tank **101** and the pump **100**. The heat is exhausted to the outside of the image forming device at the radiator **103**. The cooling liquid that is cooled down up to nearly room temperature since the heat is dissipated by the radiator **103** is thereafter fed to the cooling roller **22** again. The paper P that was heated by the heat fixing unit **16** to have a high temperature is efficiently cooled down by the heat exhaust cycle of a high cooling performance using the cooling liquid. Therefore, at a point of time when the paper P is stacked on the discharged paper receiving unit **17**, the toner on the paper P can be hardened with high degree of certainty. It is thus possible to avoid the blocking phenomenon that has been a big problem, in particular, in two-sided image formation output.

Hereinafter, examples of an image forming device of an electronic photography technique according to the present invention will be explained.

Example 1

The cooling roller **22** of the present invention was applied to a modified device of a color image forming device "Imagio Neo C600" made by Ricoh Co., Ltd. "Imagio Neo C600" employs a tandem-type and an indirect transfer technique illustrated in FIG. **22**.

The cooling roller **22** was configured such that the coil-like member **2** having a line thickness of 0.5 [mm] and a pitch of 6 [mm] was inserted along the inner wall of the outer tube **1**, made of aluminum, having an outer diameter of ϕ30.4 [mm] and a thickness of 1.1 [mm], and two rotary joints for a one-way flow made by Showa Giken Industrial Corporation were sealably and rotatably mounted to both ends of the cooling roller.

Two corrugated radiators (thickness 20 [mm]) that have a square shape having one side of 120 [mm] and are made of aluminum were connected in series. An axial flow fan (flow velocity 2.3 [m/s]) that has the same size as the radiator and has a square shape having one side of 120 [mm] was used as the radiator fan. A centrifugal type having a shut-off head of 50 [kPa] was used as the pump. A tank that has a volume of 700 [mL] and is made of polypropylene was used as the tank. A rubber tube made of a butyl rubber-EPDM mixture was used as the tube. As the circulated cooling liquid, a liquid of a −13° C. anti-freeze specification that includes propylene glycol as a main component and also includes a rust preventing agent was selected.

Through such a configuration, color two-sided continuous printing that was performed for 75 sheets per one minute was continuously performed for three hours on a gloss coat (158 [g/m^2]) and a POD film coat S [(198 [g/m^2]) that are coat papers produced by Oji Paper Co., Ltd. In order to measure the temperature of the paper, thin thermocouples were disposed in a paper transport passage between the fixing device and the cooling device and in a paper transport passage at a downstream side of the cooling roller **22** in the paper transport direction, and temperatures when the paper contacted the thermocouples were measured. As a result, as a paper temperature reduction effect, in the case of using the gloss coat produced by Oji Paper Co., Ltd., the paper temperature after cooled by the cooling roller **22** was lowered by 35° C. compared to the paper temperature before the paper after fixing us cooled down by the cooling roller **22**. Further, in the case of using the POD film coat S, the paper temperature after cooled by the cooling roller **22** was lowered by 30° C. compared to the paper temperature before the paper after fixing is cooled down by the cooling roller **22**. Further, a problem such as curl or adhesion was not found on the paper.

Example 2

As the cooling roller **22** of Example 2, employed was a configuration in which the outer tube **1** is made of aluminum and has an outer diameter of ϕ30.4 [mm] and a thickness of 1.1 [mm], the inner tube **7** is made of aluminum, the cylinder **8** is mounted in the inner tube **7**, and the coil-like member **2** having a line thickness of 0.5 [mm] and a pitch of 16 [mm] is inserted along the inner wall of the outer tube **1**. Further, a configuration, in which a rotary joint for a two-way flow made by Showa Corporation is sealably and rotatably mounted to a one end of the cooling roller **22**, was employed. In this time, the inner tube **7** had an outer diameter of ϕ4 [mm], and a space between the outer tube **1** and the cylinder **8** was 1.1 [mm].

By such a configuration, color two-sided continuous printing that was performed for 75 sheets per one minute was continuously performed for four hours. In order to measure the temperature of the paper, thin thermocouples were disposed in a paper transport passage between the fixing device and the cooling device and in a paper transport passage at a downstream side of the cooling roller **22** in the paper transport direction, and temperatures when the paper contacted the thermocouples were measured. As a result, as a paper temperature reduction effect, in the case of using the gloss coat produced by Oji Paper Co., Ltd., the paper temperature after cooled by the cooling roller **22** was lowered by 39° C. compared to the paper temperature before the paper after fixing is cooled down by the cooling roller **22**. Further, in the case of using the POD film coat S, the paper temperature after cooled by the cooling roller **22** was lowered by 33° C. compared to the paper temperature before the paper after fixing is cooled by the cooling roller **22**. Further, a problem such as curl or adhesion was not found on the paper.

Comparative Example

Next, comparative Examples to the above examples, in which the coil-like members **2** disposed inside the cooling rollers **22** in Example 1 and Example 2 were removed from the inside of the cooling roller **22**, will be described.

Two rotary joints for a one-way flow made of Showa Corporation were sealably and rotatably mounted to both ends of the cooling roller having the outer tube **1** that has an outer diameter of ϕ30.4 [mm] and a thickness of 1.1 [mm] and is made of aluminum. The cooling roller was applied to a modified device of a color image forming device "Imagio Neo C600" made by Ricoh Co., Ltd. "Imagio Neo C600" employs a tandem-type and an indirect transfer technique illustrated in FIG. **22**.

Two corrugated radiators (thickness 20 [mm]) that have a square shape having one side of 120 [mm] and are made of aluminum were connected in series. An axial flow fan (flow velocity 2.3 [m/s]) that has the same size as the radiator and has a square shape having one side of 120 [mm] was used as the radiator fan. A centrifugal type having a shut-off head of 50 [kPa] was used as the pump. A tank that has a volume of 700 [mL] and is made of polypropylene was used as the tank. A rubber tube made of a butyl rubber-EPD mixture was used as the tube. As the circulated cooling liquid, a liquid of a −13° C. anti-freeze specification that includes propylene glycol as a main component and also includes a rust preventing agent was selected.

Through such a configuration, color two-sided continuous printing that was performed for 75 sheets per one minute was continuously performed for three hours on a gloss coat (158 [g/m^2]) and a POD film coat S [(198 [g/m^2]) that are coat papers produced by Oji Paper Co., Ltd. In order to measure the temperature of the paper, thin thermocouples were disposed in a paper transport passage between the fixing device and the cooling device and in a paper transport passage at a downstream side of the cooling roller in the paper transport direction, and temperatures when the paper contacted the thermocouples were measured. As a result, as a paper temperature reduction effect, in the case of using the gloss coat produced by Oji Paper Co., Ltd., the paper temperature after cooled by the cooling roller **22** was lowered by 33° C. compared to the paper temperature before the paper after fixing is cooled down by the cooling roller. Further, in the case of using the POD film coat S, the paper temperature after cooled by the cooling roller was lowered by 27° C. compared to the paper temperature before the paper after fixing is cooled down by the cooling roller. Further, a problem such as curl or adhesion was not seen on the paper.

As can be understood from the experimental results of Examples 1 and 2 and Comparative Example, when the coil-like member **2** is disposed inside the cooling roller **22** to actively generate the turbulence near the inner wall of the cooling roller **22**, the paper temperature reduction effect can be improved more than when the coil-like member **2** is not disposed inside the cooling roller **22**.

As described above, according to the present embodiment, in the cooling device **18** that includes the cooling roller **22** having the outer tube **1** that is the hollow tubular member and the pump **100** that is a cooling medium transport unit for transporting the cooling liquid into the cooling roller **22** and makes the paper P contact the cooling roller **22** to cool down the paper P, the turbulence generating unit that generate the turbulence in the cooling liquid is disposed near the inner wall of the outer tube **1**, and so the flow of the cooling liquid is converted to the turbulence near the inner wall by the turbulence generating unit. As a result, the cooling liquid having a high temperature near the inner wall and the cooling liquid having a low temperature at a location away from the inner wall are actively interchanged. Therefore, the temperature of the cooling liquid can be lower than when the turbulence generating unit is not disposed near the inner wall, and thus the cooling roller **22** can be effectively cooled down by the cooling liquid as much. Accordingly, the cooling efficiency of the paper P by the cooling roller can be improved.

Further, according to the present embodiment, by employing a configuration in which the turbulence generating unit is detachably attached to the outer tube **1**, a complicated process for forming a groove or a slit in the outer tube **1** in advance in order to provide the turbulence generating unit is not necessary, and the turbulence generating unit can be attached as an add-on and can be easily replaced for maintenance.

Further, according to the present embodiment, provided may be a dual tube structure in which the inner tube **7** with the finer tubular structure more than the outer tube **1** is disposed in the hollow inside of the outer tube **1** that is the tubular member, and an outside flow passage in which the cooling liquid flows between the outer tube **1** and the inner tube **7** and an inside flow passage in which the cooling liquid flows inside the inner tube **7** are formed. Thereby, the flow passage of the cooling liquid can be divided into the space between the outer tube **1** and the inner tube **7** and the inside of the inner tube **7**, and thus one can be used as the forward passage of the flow of the cooling liquid, and the other can be used as the return passage of the flow of the cooling liquid. Therefore, the inflow and outflow passages of the cooling liquid can be formed at a one end of the cooling roller **22** in the axial direction. Thus, the space can be saved compared to the case where the inflow and outflow passages of the cooling liquid are formed at different ends of the cooling roller **22** in the axial direction. Further, the cooling roller **22** can be easily mounted in the cooling device **18** or the image forming device.

Further, according to the present embodiment, the cylinder **8** having a diameter larger than the inner tube **7** may be mounted in the hollow inside of the outer tube **1** so as to surround the inner tube **7**. According to this configuration, the space between the outer tube **1** and the cylinder **8** is narrowed and thus the flow velocity of the cooling liquid increases near the inner wall of the outer tube, and the heat transfer rate between the roller inner wall and the cooling liquid increases, whereby the cooling efficiency of the paper P is improved.

Further, according to the present embodiment, the inner tube **7** may be disposed to rotate with a different rotation number in the same direction as the rotation direction of the outer tube **1**, rotate in a direction reverse to the rotation direction of the outer tube **1**, or in a fixed state, According to this configuration, in the flow passage configured with the space between the outer tube **1** and the inner tube **7**, the rotation speed component increases, and so the generation of the turbulence of the cooling liquid by the turbulence generating unit can be promoted. Therefore, more separation or adhesion of the flow of the cooling liquid occurs throughout the inner wall of the outer tube, and the cooling efficiency of the paper P can be further improved.

Further, according to the present embodiment, the cylinder **8** may be disposed to rotate with a different rotation number in the same direction as the rotation direction of the outer tube **1**, rotate in a direction reverse to the rotation direction of the outer tube **1**, or in a fixed state. According to this configuration, in the flow passage configured with the space between the outer tube **1** and the cylinder **8**, the rotation speed component increases, and the turbulence generation of the cooling liquid by the turbulence generating unit described above can be promoted. Therefore, more separation or adhesion of the flow of the cooling liquid occurs throughout the inner wall of the outer tube, and the cooling efficiency of the paper P can be further improved.

Further, according to the present embodiment, the turbulence generating unit may be disposed in an area extending in the longitudinal direction of the outer tube **1** where the paper P is held. According to this configuration, the fluid resistance caused by the turbulence generating unit is not generated in sections other than the area, and thus the load of the pump is reduced, and the power consumption is reduced. Further, a pump lower than one rank can be used, and the cost can be reduced. Further, as the power consumption of the pump is reduced, durable time is increased.

Further, according to the present embodiment, the turbulence generating unit may be disposed in an area extending in the circumferential direction of the outer tube **1** where the paper P is held. According to this configuration, the fluid resistance caused by the turbulence generating means is not generated in the sections other than the area, and thus the load of the pump is reduced, and the power consumption is reduced. Further, a pump lower than one rank can be used, and the cost can be reduced. Further, when the power consumption of the pump is reduced, durable time is increased.

Further, according to the present embodiment, the vibrating unit for vibrating the turbulence generating unit may be disposed. According to this configuration, the turbulence generating unit is vibrated, so that the flow velocity of the cooling liquid near the turbulence generating unit increases. Therefore, the turbulence generation of the cooling liquid by the turbulence generating unit described above can be promoted. As a result, more separation or adhesion of the flow of the cooling liquid occurs throughout the inner wall of the outer tube, whereby the cooling efficiency of the paper P can be further improved.

Further, according to the present embodiment, by employing a configuration in which the turbulence generating unit is the coil-like member, the cooling roller **22** of the present invention can be easily implemented at a low cost.

Further, according to the present embodiment, the turbulence generating unit may be the net-like member. According to this configuration, the cooling roller **22** of the present invention can be easily implemented at a low cost, for example, by employing a configuration in which a metal net is formed to have a cylindrical shape having a diameter slightly smaller than the outer tube **1** and inserted into the outer tube **1**.

Further, according to the present embodiment, the turbulence generating unit may have the helical shape, and the winding direction of the helical shape may be set to the winding direction that causes the feeding in a direction reverse to the flow direction of the cooling liquid flowing near the inner wall of the outer tube **1**. According to this configuration, the turbulence is further generated in the cooling liquid near the inner wall of the outer tube **1**, so that the cooling performance is further improved. Thus, the cooling efficiency of the paper P can be improved.

Further, according to the present embodiment, the core **31** as the core member may be disposed in the hollow inside of the outer tube **1**, and the flow passage in which the cooling liquid flows may be formed in the space formed between the outer tube **1** in which the turbulence generating unit is disposed and the core **31**. According to this configuration, the cooling liquid flows through the flow passage of the narrow space in which the core **31** is disposed thereinside, and thus the flow velocity of the cooling liquid increases near the inner wall of the outer tube, and the heat transfer rate between the roller inner wall and the cooling liquid increases, and the cooling efficiency of the paper P is also improved.

Further, according to the present embodiment, the second turbulence generating unit for generating the turbulence in the cooling liquid near the outer circumferential surface of the core **31** may be disposed. According to this configuration, the more complicated and larger turbulence is generated in the flow passage space, and thus the heat transfer rate between the roller inner wall and the cooling liquid is further increased, and the cooling efficiency of the paper P can be improved.

Further, according to the present embodiment, the second turbulence generating unit for generating the turbulence in the cooling liquid near the outer circumferential surface of the inner tube **7** may be disposed. According to this configuration, the more complicated and larger turbulence is generated in the flow passage space, and thus the heat transfer rate between the roller inner wall and the cooling liquid is further increased, and the cooling efficiency of the paper P is improved.

Further, according to the present embodiment, the second turbulence generating unit for generating the turbulence in the cooling liquid near the outer circumferential surface of the cylinder **8** may be disposed. According to this configuration, the more complicated and larger turbulence is generated in the flow passage space, and thus the heat transfer rate between the roller inner wall and the cooling liquid is further increased, and the cooling efficiency of the paper P is improved.

Further, according to the present embodiment, the core **31** may be disposed to rotate with a different rotation number in the same direction as the rotation direction of the outer tube **1**, rotate in a direction reverse to the rotation direction of the outer tube **1**, or in a fixed state. According to this configuration, in the flow passage of the narrow space formed by including the core **31** inside the outer tube **1**, the rotation speed component is increased, and the generation of the turbulence of the cooling liquid by the turbulence generating unit described above can be promoted. Therefore, more separation or adhesion of the flow of the cooling liquid occurs throughout the inner wall of the outer tube, and the cooling efficiency of the paper P can be further improved.

Further, according to the present embodiment, in the image forming device including the toner image forming unit for forming the toner image on the paper P, the heat fixing unit **16** for fixing the toner image, which is formed on the paper P, on the paper P by at least heat, and the cooling unit for cooling down the paper P on which the toner image is fixed by the heat fixing unit **16**, the cooling efficiency can be improved by using the cooling device **18** having the cooling roller **22** of the present invention as the cooling unit.

Second Embodiment

Next, a cooling device according to a second embodiment will be described with reference to FIGS. **23** to **41**. Here, configuration examples of a cooling roller **110** different from the cooling roller **22** of the cooling device **18** according to the first embodiment described above will be described. A cooling device that is the same as the cooling device illustrated in FIG. **2** regarding an overall configuration is used, and duplicated description will be omitted. Further, a configuration of an image forming device in which the cooling device according to the present embodiment is mounted is also the same as that in FIG. **22**, and thus duplicated description is omitted in the present embodiment.

Configuration Example 1

Next, a cooling roller **110** according to a configuration example 1 is illustrated in FIG. **23**. FIG. **23** is a schematic cross-sectional view of a cooling roller in which rotating tube joint units **111** are mounted to both ends of the cooling roller **110** in the axial direction, and two independent flow passages are formed in the axial direction of the cooling roller **110**.

Hereinafter, when discrimination is necessary, components at a first rotating tube joint unit **110***a* side of the cooling roller **110** are designated as "a" behind reference numeral, and components at a second rotating tube joint unit **110***b* side of the cooling roller **110** are designated as "b" behind reference numeral.

In FIG. **24**, the cooling liquid is fed from a feed port **113***a* of a first rotating joint unit **111***a* to the cooling roller **110**, passes through an outside flow passage **116***a* (a forward flow passage) that is a space between an outer tube **114** and an inner tube **115***a*, is returned by a flow passage wall **117**, which separates a flow passage **112***a* and a flow passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through an inside flow passage **118***a* (a return flow passage) inside the inner tube **115***a*, and is drained from a drain port **119***a* of the first rotating tube joint unit **111***a*.

Similarly, the cooling liquid is fed from a feed port **113***b* of a second rotating joint unit **111***b* to the cooling roller **110**, passes through an outside flow passage **116***b* (a forward flow passage) that is a space between an outer tube **114** and an inner tube **115***b*, is returned by the flow passage wall **117**, which separates the flow passage **112***a* and the flow passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through an inside flow passage **118***b* (a return flow passage) inside the inner tube **115***b*, and is drained from a drain port **119***b* of the second rotating tube joint unit **111***b*.

In this way, the cooling roller **110** has the two independent flow passages **112***a* and **112***b* in which reciprocating circulation is performed. Therefore, the cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and forms a closed-loop flow passage together with a cooling liquid circulating unit which will be described later through rotating tube joint unit **111***a* and **111***b* to circulate the cooling liquid.

Next, FIG. **25** is a schematic cross-sectional view of the cooling roller **110** in which the cooling roller **110** is modified to allow the cooling liquid to easily flow from the outside flow passage **116** to the inside flow passage **118** compared the cooling roller **110** illustrated in FIG. **24**.

In the cooling roller **110** illustrated in FIG. **24**, since the cooling liquid that flows in through the outside flow passage **116** collides with the flow passage wall **117**, it is not easy for the cooling liquid to flow into the inside flow passage **118**, and opposite flow may be generated near the flow passage wall **117**. For this reason, flow passage auxiliary walls **123***a* and **123***b* having an angle for guiding the flow of the cooling liquid in the direction of the inside flow passage **118** from the outside flow passage **116** are formed in the flow passage wall **117** as illustrated in FIG. **25**. Due to the same reason, even though not shown, the flow passage wall **117** may have a shape with a curvature. According to the configuration in which the flow passage auxiliary walls **123***a* and **123***b* are formed in the flow passage wall **117**, the cooling liquid smoothly flows to the inside flow passage **118** from the outside flow passage **116**, thereby increasing the cooling efficiency.

Configuration Example 2

Next, a cooling roller **110** according to a configuration example 2 is illustrated in FIGS. **26**A and **26**B. FIG. **26**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and a flow passage **112***a* and a flow passage **112***b* are communicated with each other through a flow port **120**. FIG. **26**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **26**A is viewed in a direction of an arrow X**6** in the drawing.

In FIGS. **26**A and **26**B, the cooling liquid is fed from the feed port **113***a* of the first rotating joint unit **111***a* to the inside of the cooling roller **110**, passes through an outside flow passage **116***a* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115**, passes through an inside flow passage **118***a* (the return flow passage) or an inside flow passage **118***b* (the return flow passage) inside the inner tube **115** via a flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from a drain port **119***a* of the first rotating tube joint unit **111***a* or a drain port **119***b* of the second rotating tube joint unit **111***b*.

Similarly, the cooling liquid is fed from the feed port **113***b* of the second rotating joint unit **111***b* to the inside of the cooling roller **110**, passes through an outside flow passage **116***b* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118***a* (the return flow passage) or the inside flow passage **118***b* (the return flow passage) inside the inner tube **115** via the flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119***a* of the first rotating tube joint unit **111***a* or the drain port **119***b* of the second rotating tube joint unit **111***b*.

In this way, the cooling roller **110** has the two independent flow passages **112***a* and **112***b* in which the cooling liquid flows through the flow port **120**. Therefore, the cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and forms the closed-loop flow passage together with a cooling liquid circulating unit which will be described later through the first rotating tube joint unit **111***a* and the second rotating tube joint unit **111***b* to circulate the cooling liquid. Since the inner tube **115** is formed with such a simplified shape, the cost can be reduced.

Configuration Example 3

Next, a cooling roller **110** according to a configuration example 3 is illustrated in FIGS. **27**A and **27**B. FIG. **27**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint units **111** are mounted to both axial direction ends of the cooling roller **110**, a flow passage **112***a* and a flow passage **112***b* are communicated with each other through a flow port **120**, and an inside flow passage **118** inside the inner tube **115** and a drain port **119** are formed only at any one side of the first rotating tube joint unit **111***a* side and the second rotating tube joint unit **111***b* side. FIG. **27**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **27**A is viewed in a direction of an arrow X**7** in the drawing.

In FIGS. **27**A and **27**B, the cooling liquid is fed from the feed port **113***a* of the first rotating joint unit **111***a* to the inside of the cooling roller **110**, passes through the outside flow passage **116***a* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118***a* (the return flow passage) inside the inner tube **115** via the flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119***a* of the first rotating tube joint unit **111***a*.

Further, the cooling liquid is fed from the feed port **113***b* of the second rotating joint unit **111***b* to the inside of the cooling roller **110**, passes through the outside flow passage **116***b* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118***a* (the return flow passage) inside the inner tube **115** via the flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119***a* of the first rotating tube joint unit **111***a*.

In this way, the cooling roller **110** has the two flow passages **112***a* and **112***b* in which the cooling liquid flows through the flow port **120**. Therefore, the cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and form the closed-loop flow passage together with the cooling liquid circulating unit which will be described later through the first rotating tube joint unit **111***a* and the second rotating tube joint unit **111***b* to circulate the cooling liquid.

Modified Example

As illustrated in FIG. **28**, a flow passage auxiliary wall **124** that guides the cooling liquid flowing in from the outside flow passage **116** to the inside flow passage **118***a* is formed on an end portion of the inner tube **115***b* at the flow port **120** side. Therefore, the cooling liquid flowing in through the outside flow passage **116** can be easily flowed into the inside flow passage **118** through the flow port **120**.

Configuration Example 4

Next, a cooling roller **110** according to a configuration example 4 is illustrated in FIGS. **29**A and **29**B. FIG. **29**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint units **111** are mounted to both axial direction ends of the cooling roller **110**, the two independent passages **112** are formed, and return positions in the longitudinal direction of the cooling roller **110** are changed depending on a position along the circumferential direction. FIG. **29**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **29**A is viewed from directly above in the drawing.

In FIGS. **29**A and **29**B, the cooling liquid is fed from the feed port **113***a* of the first rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the outside flow passage **116***a* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115***a*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the inside flow passage **118***a* (a return flow passage) inside the inner tube **115***a*, and is drained from the drain port **119***a* of the first rotating tube joint unit **111***a*.

Similarly, the cooling liquid is fed from the feed port **113***b* of the second rotating tube joint unit **111***b* to the inside of the cooling roller **110**, passes through the outside flow passage **116***b* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115***b*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the inside flow passage **118***b* (the return flow passage) inside the inner tube **115***b*, and is drained from the drain port **119***b* of the second rotating tube joint unit **111***b*.

Here, in order to eliminate a spot that can not be cooled locally over one round in a circumferential direction since the cooling liquid is not passed to the outside flow passage **116** at the spot, the flow passage wall **117** is disposed obliquely with respect to the longitudinal direction of the cooling roller **110**. The inner tube **115***a* and the inner tube **115***b* have oblique cross sections so that the return positions is changed depending on a position along the circumferential direction and disposed such that a position in the longitudinal direction of the cooling roller **110** is varied.

In this way, the cooling roller **110** has the two independent flow passages **112***a* and **112***b* in which the cooling liquid flows. Therefore, the cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and forms the closed-loop flow passage together with the cooling liquid circulating unit which will be described later through the first rotating tube joint unit **111***a* and the second rotating tube joint unit **111***b* to circulate the cooling liquid.

Configuration Example 5

Next, a cooling roller **110** according to a configuration example 5 is illustrated in FIGS. **30**A and **30**B. FIG. **30**A is a schematic cross-sectional view of a cooling roller **110** in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the two independent flow passages **112***a* and **112***b* are formed. FIG. **30**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **30**A is viewed in a direction of an arrow X**10** in the drawing.

The outer tube **114** rotates. One end side of the inner tube **115***a* is fixedly supported to the first rotating tube joint unit **111***a* not to rotate, and the other end side is rotatably supported to the flow passage wall **117** through a bearing (not shown). One end side of the inner tube **115***b* is fixedly supported to the second rotating tube joint unit **111***b* not to rotate, and the other end side is rotatably supported to the flow passage wall **117** through a bearing (not shown). A flow port **120***a* is formed in the inner tube **115***a* near the flow passage wall **117** to allow the cooling liquid to flow from the outside flow passage **116***a* to the inside flow passage **118***a*. A flow port **120***b* is formed in the inner tube **115***b* near the flow passage wall **117** to allow the cooling liquid to flow from the outside flow passage **116***b* to the inside flow passage **118***b*.

The cooling roller **110** having such a configuration generates the turbulence in the flow (the flow in the axial direction and the rotation direction) of the cooling liquid inside the outside flow passage **116**, particularly, near the inside of the outer tube **114**, thereby increasing the cooling efficiency.

Configuration Example 6

Next, a cooling roller **110** according to a configuration example 6 is illustrated in FIGS. **31**A and **31**B. FIG. **31**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and two passages **112***a* and **112***b* are communicated with each other through the flow port **120**. The outer tube **114** rotates, and both ends of the inner tube **115** are rotatably supported to the rotating tube joint unit ill. FIG. **31**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **31**A is viewed in a direction of an arrow X**11** in the drawing. FIG. **32** is a cross-sectional view when a cross section of the cooling roller **110** taken along line Y-Y' of FIG. **31**A is viewed in the longitudinal direction of the cooling roller **110**.

In the present configuration example, as illustrated in FIG. **32**, the outer tube **114** and the inner tube **115** are locally fixed by a coupling support unit **121**. Therefore, the outer tube **114** and the inner tube **115** rotate together. Preferably, the coupling support unit **121** has a mechanical strength that can endure a load generated when the outer tube **114** and the inner tube **115** rotate together and has a structure that disturbs the flow of the cooling liquid flowing through the outside flow passage **116** as little as possible.

The cooling roller **110** having such a configuration makes smooth the flow (in the axial direction and the rotation direction) of the cooling liquid inside the outside flow passage **116**, thereby increasing the cooling efficiency.

Configuration Example 7

Next, a cooling roller **110** according to a configuration example 7 is illustrated in FIGS. **33**A and **33**B. FIG. **33**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the two passages **112***a* and **112***b* are communicated with each other through the flow port **120**. FIG. **33**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **33**A is viewed in a direction of an arrow X**13** in the drawing.

A flow passage auxiliary wall **122** is fixed to the inner wall of the outer tube **114** between a spot of the inner tube **115** where the flow port **120** is formed and the outer tube **114**. The cooling liquids flowing in through the outside flow passages **116***a* and **116***b* easily flow into the inside flow passage **118** through the flow port **120**.

When the inner tube **115** does not rotate or when the outer tube **114** and the inner tube **115** rotate together, the flow passage auxiliary wall **122** can be formed to extend up to the inside of the flow port **120**. However, when the outer tube **114** and the inner tube **115** asynchronously rotate, the flow passage auxiliary wall **122** needs to be disposed inside the outside flow passage **116** not to contact the inner tube **115**.

The flow passage auxiliary wall **122** has an effect of preventing opposite flow from being generated when the cooling liquid flowing in through the outside flow passage **116***a* and the cooling liquid flowing in through the inside flow passage **116***b* collide with each other at a position of the flow port **120** and making smooth the flow of the cooling liquid.

Further, as illustrated in FIG. **34**, even when the inner tube **115** is divided into an inner tube **115***a* and an inner tube **115***b*, the flow passage auxiliary wall **122** may be disposed to be fixed to the inner wall of the outer tube **114** near the passages **112***a* and **112***b*. In this case, it is possible to enable the cooling liquids flowing in through the outside flow passages **116***a* and **116***b* to easily flow into the inside flow passages **118***a* and **118***b* through the passages **112***a* and **112***b*.

Configuration Example 8

Next, a cooling roller **110** according to a configuration example 8 is illustrated in FIGS. **35**A and **35**B. FIG. **35**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both ends of the cooling roller **110** in the axial direction, and the two passages **112***a* and **112***b* are communicated with each other through the flow port **120**. FIG. **35**B is a cross-sectional view when the cooling roller **110** illustrated in FIG. **35**A is viewed in a direction of an arrow X**15** in the drawing.

In the present configuration example, at least two flow ports **120***a* and **120***b* that allow the outside flow passage **116** and the inside flow passage **118** to communicate with each other are formed in the inner tube **115**. Positions where the cooling liquids are returned in the longitudinal direction of the cooling roller **110** are different in the circumferential direction.

At a circumferential direction position A of the cooling roller **110** of FIG. **35**A, the cooling liquid is fed from the feed port **113***a* of the first rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the outside flow passage **116***a* that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118***a* or the inside flow passage **118***b* inside the inner tube **115** through the flow port **120***a* present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119***a* of the first rotating tube joint unit **111***a* or the drain port **119***b* of the second rotating tube joint unit **111***b*.

Similarly, the cooling liquid is fed from the feed port **113**b of the second rotating tube joint unit **111**b to the inside of the cooling roller **110**, passes through the outside flow passage **116**b that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118**a or the inside flow passage **118**b inside the inner tube **115** through the flow port **120**a present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119**a of the first rotating tube joint unit **111**a or the drain port **119**b of the second rotating tube joint unit **111**b.

At a circumferential direction position B of the cooling roller **110** of FIG. **35**A, the cooling liquid is fed from the feed port **113**a of the first rotating tube joint unit **111**a to the inside of the cooling roller **110**, passes through the outside flow passage **116**a that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118**a or the inside flow passage **118**b inside the inner tube **115** through the flow port **120**b present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119**a of the first rotating tube joint unit **111**a or the drain port **119**b of a second rotating tube joint unit **111**b.

Similarly, the cooling liquid is fed from the feed port **113**b of the second rotating tube joint unit **111**b to the inside of the cooling roller **110**, passes through the outside flow passage **116**b that is a space between the outer tube **114** and the inner tube **115**, passes through the inside flow passage **118**a or the inside flow passage **118**b inside the inner tube **115** through the flow port **120**b present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **119**a of the first rotating tube joint unit **111**a or the drain port **119**b of the second rotating tube joint unit **111**b.

As described above, a plurality of flow ports formed in the inner tube **115** are disposed at different positions in the circumferential direction of the cooling roller **110**. When the cooling liquids flowing in through the outside flow passages **116** at different positions in the circumferential direction flow into the inside flow passage **118**, the cooling liquids flowing into the inside flow passage **118** from the different flow ports **120** do not collide with each other. Therefore, opposite flow or the turbulence can be reduced, and the flow of the cooling liquid from the outside flow passage **116** to the inside flow passage **118** becomes smooth, thereby increasing the cooling efficiency.

Configuration Example 9

Next, a cooling roller **110** according to a configuration example 9 is illustrated in FIG. **36**. FIG. **36** is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the passage **112**a and the passage **112**b are communicated with each other through the flow port **120**. The paper P that became a high temperature while passing through the heat fixing unit **16** (see FIG. **2**) is transported in a direction orthogonal to the longitudinal direction of the cooling roller **110**.

In FIG. **36**, the cooling liquid is fed from the feed port **113**a of a first rotating tube joint unit **111**a to the inside of the cooling roller **110**, passes through the outside flow passage **116**a that is a space between the outer tube **114** and the inner tube **115**a, is returned by the flow passage wall **117**, which separates the passage **112**a and the passage **112**b, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the inside flow passage **118**a inside the inner tube **115**a, and is drained from the drain port **119**a of the first rotating tube joint unit **111**a.

Similarly, the cooling liquid is fed from the feed port **113**b of the second rotating tube joint unit **111**b to the inside of the cooling roller **110**, passes through the outside flow passage **116**b that is a space between the outer tube **114** and the inner tube **115**b, is returned by the flow passage wall **117**, which separates the passage **112**a and the passage **112**b, present in the middle in the longitudinal direction of the cooling roller, passes through the inside flow passage **118**b inside the inner tube **115**b, and is drained from the drain port **119**b of the second rotating tube joint unit **111**b.

Therefore, if heat is not received from the outside except the paper P, directly after the cooling liquid is fed to the cooling roller **110**, the temperature of the cooling liquid flowing through the outside flow passage **116** of the cooling roller **110** and the surface temperature of the outer tube **114** of the cooling roller **110** are lowest at the first rotating tube joint unit **111**a side or the second rotating tube joint unit **111**b side and are highest near the flow passage wall **117**.

For this reason, in the present configuration example, the paper P is transported in the longitudinal direction of the cooling roller **110** so that a central position of the paper P can pass through a position of the flow passage wall **117**. As a result, the outer tube **114** of the cooling roller **110** is cooled down with a temperature gradient that becomes equal left and right in the width direction of the paper P, and the passages **112**a and **112**b are deprived of the same heat quantity. Therefore, it is possible to prevent the temperature of the cooling liquid from being greatly increased in any one of the passages **112**.

Further, since the outer tube **114** of the cooling roller **110** is cooled down with the temperature gradient that is equal left and right in the width direction of the paper P, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, when the cooling roller **110** of a structure that does not have the flow passage wall **117** formed in the cooling roller **110** is used in the present configuration example, the paper P is preferably transported in the longitudinal direction of the cooling roller **110** so that the central position of the paper P can pass through the central position of the flow port **120**.

Here, if the width of the paper P is smaller than the length of the outside flow passage **116**a, the cooling liquid is passed only to the passage **112**a, and the paper P is transported on the outside flow passage **116**a of the cooling roller **110** as illustrated in FIG. **37**. As described above, the paper P is cooled down by passing the cooling liquid only to one flow passage, thereby saving the energy and increasing the lift span of the cooling device **18**.

In FIG. **37**, the outside flow passage **116**a is identical in length to the outside flow passage **116**b. However, the outside flow passage **116**a may be different in length from the outside flow passage **116**b. In this case, the width of the paper P is detected. If the width of the paper P is smaller than both of the length of the outside flow passage **116**a and the length of the outside flow passage **116**b, the paper P can be transported on either of the outside flow passage **116**a and the outside flow passage **116**b. However, if the width of the paper P is larger than one of the length of the outside flow passage **116**a and the length of the outside flow passage **116**b and smaller than the other, the paper P is preferably transported on the outside flow passage **116**a or the outside flow passage **116**b that has the length larger than the width of the paper P.

Next, a case where the cooling liquid **102** is fed through one feed unit will be described with reference to FIG. **38**.

In a cooling circulation device **150**, illustrated in FIG. **38**, used in the cooling device **18**, the cooling liquid **102** inside the tank **101** is fed by the pump **100**, and when passing through a radiator **154** that is a heat radiation unit, a cooling fan **153** blows air to radiate heat to the outside, thereby lowering the temperature of the cooling liquid **102** (heat exchange between the cooling liquid **102** and the outside). The cooling liquid **102** cooled down by the radiator **154** is fed to the inside of the cooling roller **110** from the feed port **113***a* of the first rotating tube joint unit **111***a* and the feed port **113***b* of the second rotating tube joint unit **111***b*, which are mounted to both axial direction ends of the cooling roller **110** via a liquid feed tube **155** and flows through the passage **112***a* or the passage **112***b* inside the cooling roller **110**. At this time, the cooling roller **110** deprives the paper P, which became a high temperature while passing through the heat fixing unit **16**, of heat, so that the temperature of the cooling liquid **102** inside the cooling roller **110** is raised (heat exchange between the cooling liquid **102** and the paper P). The cooling liquid **102** that was raised in temperature inside the cooling roller **110** is drained from the drain port **119***a* of the first rotating tube joint unit **111***a* or the drain port **119***b* of the second rotating tube joint unit **111***b* and is fed again by the pump **100** via the tank **101**. Through the circulation of the cooling liquid **102**, radiating heat of the paper P to the outside of the cooling device **18** is repeated.

In the cooling circulation device **150** illustrated in FIG. **38**, if the flow passage to the cooling roller **110** from after going out of the radiator **154** and the flow passages of the passage **112***a* side and the passage **112***b* side of the cooling roller **110** are the same in structure, feeding can be performed by one pump **100**, so that the feed port **113***a* and the feed port **113***b* have the same flow quantity and pressure. Therefore, the cooling roller **110** can have the cooling efficiency that is symmetrical at the left side and the right side of the flow passage wall **117**.

Next, a case where the cooling liquid **102** is fed through two feed unit will be described with reference to FIG. **39**.

In the cooling circulation device **150** illustrated in FIG. **39**, circulation systems of the cooling liquids **102** of the passage **112***a* and the passage **112***b* of the cooling roller **110** have independent flow passages.

A cooling liquid **102***a* inside a tank **101***a* is fed by the pump **100***a*, and when passing through a radiator **154***a*, a cooling fan **153***a* blows air to radiate heat to the outside, thereby lowering the temperature of the cooling liquid **102***a* (heat exchange between the cooling liquid **102***a* and the outside). The cooling liquid **102***a* cooled down by the radiator **154***a* is fed to the inside of the cooling roller **110** from the feed port **113***a* of the first rotating tube joint unit **111***a*, which is mounted to an axial direction one end of the cooling roller **110**, through a feed tube **155***a*, and flows through the passage **112***a* inside the cooling roller **110**. At this time, the cooling roller **110** deprives the paper P, which became a high temperature through the heat fixing unit **16**, of heat, so that the temperature of the cooling liquid **102***a* inside the cooling roller **110** is raised (heat exchange between the cooling liquid **102***a* and the paper P). The cooling liquid **102***a* that was raised in temperature inside the cooling roller **110** is drained from the drain port **119***a* of the first rotating tube joint unit **111***a* and is fed again by the pump **100***a* via the tank **101***a*.

Further, a cooling liquid **102***b* inside a tank **101***b* is fed by the pump **100***b*, and when passing through a radiator **154***b*, a cooling fan **153***b* blows air to radiate heat to the outside, thereby lowering the temperature of the cooling liquid **101** (heat exchange between the cooling liquid **102***b* and the outside). The cooling liquid **102***b* cooled down by the radiator **154***b* is fed to the inside of the cooling roller **110** from the feed port **113***b* of the second rotating tube joint unit **111***b*, which is mounted to an axial direction one end of the cooling roller **110**, through a feed tube **155***b*, and flows through the passage **112***b* inside the cooling roller **110**. At this time, the cooling roller **110** deprives the paper P, which became a high temperature through the heat fixing unit **16**, of heat, so that the temperature of the cooling liquid **102***b* inside the cooling roller **110** is raised (heat exchange between the cooling liquid **102***b* and the paper P). The cooling liquid **102***b* that was raised in temperature inside the cooling roller **110** is drained from the drain port **119***b* of the second rotating tube joint unit **111***b* and is fed again by the pump **100***b* via the tank **101***b*.

Therefore, when the passage **112***a* and the passage **112***b* inside the cooling roller **110** are different, when the passage **112***a* and the passage **112***b* of the cooling roller **110** are different in heat quantity received from the outside, or when the flow passages to the cooling roller **110** from after going out of the radiators **154***a* and **154***b* are different, it possible to independently control feed liquid quantities of the pumps **100***a* and **100***b*, air quantities of the cooling fans **153***a* and **153***b*, and flow quantities of the cooling liquids **102***a* and **102***b*.

Next, a mechanism of adjusting the flow quantity of the cooling liquid **102** will be described.

When the cooling circulation device **150** is mounted in the image forming device, even though the flow passage to the cooling roller **110** from after going out of the radiator **154** and the flow passages of the passage **112***a* side and the passage **112***b* side of the cooling roller **110** have the same structure, due to layout and spatial problems, the liquid feed tube **155** connected with the first rotating tube joint unit **111***a* may be different in length from the liquid feed tube **155** connected with the second rotating tube joint unit **111***b*. At this time, due to influence of pressure loss, the two passages inside the cooling roller **110**, that is, the passage **112***a* and the passage **112***b* have different cooling efficiencies. Further, in addition to the configuration difference of the circulation system, a variation of the component accuracy or a variation between lots may occur. For these reasons, a flow quantity adjusting valve **156** is connected to the liquid feed tube **155** of the cooling circulation device **150**, and thus the flow quantity can be adjusted through a mechanical mechanism.

Next, a case of detecting the temperature of the cooling liquid **102** to control the flow quantity of the cooling liquid **102** will be described. FIG. **40** illustrates an example in which a temperature detecting unit that detects the temperature of the cooling liquid **102** is disposed inside the tank **101**.

The temperature of the cooling liquid **102** detected by the temperature detecting unit **157** is feedback controlled. The flow quantity of the cooling liquid **102** is adjusted by adjusting the feed liquid quantity of the pump **100** or the flow quantity adjusting valves **156***a* and **156***b* so that the cooling liquid flowing through the passage **112***a* of the cooling roller **110** can have the same temperature as the cooling liquid flowing through the passage **112***b*.

Since the inside of the tank **101** of FIG. **40** is a common position of the passage **112***a* and the passage **112***b*, control is impossible. However, if the temperature detecting unit **157** are disposed adjacent to the flow quantity adjusting valve **156***a* and the flow quantity adjusting valve **156***b*, respectively, the flow quantities of the passage **112***a* and the passage **112***b* can be adjusted by feeding back the detected temperature of the cooling liquid **102** and controlling the flow quantity adjusting valves **156***a* and **156***b*.

In the circulation system of the cooling circulation device **150** illustrated in FIG. **39**, a method of disposing the temperature detecting unit **157** in each of the two tanks **101***a* and **101***b* or a method of disposing the temperature detecting unit **157** between the radiator **154***a* and the feed port **113***a* of the first rotating tube joint unit **111***a* and between the radiator **154***b* and the feed port **113***b* of the second rotating tube joint unit **111***b*, respectively, may be considered. Comparing the two methods, the later method of disposing the temperature detecting unit **157** between the radiator **154***a* and the feed port **113***a* and between the radiator **154***b* and the feed port **113***b*, respectively, that is, detecting at those points, has the highest accuracy since the temperatures of the cooling liquids **101***a* and **101***b* cooled down by the radiators **154***a* and **154***b* are close to the temperatures of the cooling liquids fed to the feed ports **113***a* and **113***b*. Further, a configuration that controls the temperature of the cooling liquid **102** by feeding back the temperature of the cooling liquid detected by the temperature detecting unit **157** and controlling the air quantity of the cooling fan **153** is also possible.

Next, a case of detecting the temperature near the surface of the cooling roller **110** to control the flow quantity of the cooling liquid **102** will be described.

FIG. **41** illustrates an example in which a temperature detecting unit **158** that detects the temperature near the surface of the cooling roller **110** is disposed inside the outer tube **114** of the cooling roller **110**. The temperature near the surface of the cooling roller **110** detected by the temperature detecting unit **158** is feedback controlled. The flow quantity of the cooling liquid is adjusted, for example, by adjusting the feed liquid quantity of the pump **100** or the flow quantity adjusting valves **156***a* and **156***b* illustrated in FIG. **38** so that the cooling liquid flowing through the passage **112***a* of the cooling roller **110** can have the same temperature as the cooling liquid flowing through the passage **112***b*. Further, the temperature of the cooling liquid is controlled by feeding back the temperature near the surface of the cooling roller **110** detected by the temperature detecting unit **158** and, for example, controlling the air quantity of the cooling fan **153** of FIG. **38**.

As described above, according to the present embodiment, the cooling device **18** includes the cooling roller **110** for contacting the paper P as the sheet-like member to cool down the paper P and the pump **100** that is a cooling medium feeding/retrieving unit for feeding the cooling liquid **102** as the cooling medium to the inside of the cooling roller **110** from the feed port disposed in the cooling roller **110** and retrieving the cooling liquid **101** drained to the outside of the cooling roller **110** from the drain port disposed in the cooling roller **110**. The cooling roller **110** has a dual tube structure in which the inner tube **115** is disposed inside the outer tube **114**, and the outside flow passage **116** in which the cooling liquid **102** flows through the space between the outer tube **114** and the inner tube **115** and the inside flow passage **118** in which the cooling liquids **102** flows inside the inner tube **115** are formed. An opening that allows the outside flow passage **116** and the inside flow passage **118** to communicate with each other is formed in the middle of the inner tube **115** in the longitudinal direction of the cooling roller **110**. The passage **112***a* as a first passage in which the cooling liquid **102** fed by the pump **100** flows in the outside flow passage **116** to the inside flow passage **118** in a direction from one end to the other end of the cooling roller **110** and the passage **112***b* as a second passage in which the cooling liquid **102** fed by the pump **100** flows in the outside flow passage **116** to the inside flow passage **118** in a direction from the other end to one end of the cooling roller **110** are formed. According to this configuration, the passage in which the cooling liquid **102** flows is divided into two parts in the longitudinal direction of the cooling roller **110** to cool down the cooling roller **110**. Therefore, compared to the configuration in which the cooling liquid **102** flows in one direction in the longitudinal direction of the cooling roller **110**, the temperature increment of the cooling roller **110** can be further reduced. Further, the temperature difference in the longitudinal direction and the temperature difference between both ends of the cooling roller **10** can be reduced. Further, uniform image quality and gloss can be obtained in the width direction of the cooling roller **110**. Moreover, the temperature control can be performed symmetrically in the longitudinal direction of the cooling roller **110**, and thus the curl of the paper P can be reduced.

Further, according to the present embodiment, a configuration may be employed in which the opening is formed in a central portion of the inner tube **115** in the longitudinal direction of the cooling roller; at one end side of the cooling roller **110**, a first feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a first drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; at the other end side of the cooling roller **110**, a second feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a second drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; the cooling liquid **102** fed from the first feed port, in the passage **112***a*, flows through the outside flow passage **116**, flows into the inside flow passage **118** through the opening, and is drained from at least one of the first drain port and the second drain port; and the cooling liquid **102** fed from the second feed port, in the passage **112***b*, flows through the outside flow passage **116**, flows into the inside flow passage **118** through the opening, and is drained from at least one of the first drain port and the second drain port. Therefore, since the configuration of the cooling roller **110** is simplified, the cost of the cooling device **18** can be reduced.

Further, according to the present embodiment, a configuration may be employed in which the opening is formed in a central portion of the inner tube **115** in the longitudinal direction of the cooling roller; at one end side of the cooling roller **110**, a first feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** is formed; at the other end side of the cooling roller **110**, a second feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** is formed; a drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** is formed at any of one end side and the other end side of the cooling roller **110**; the cooling liquid **102** fed from the first feed port, in the passage **112***a*, flows through the outside flow passage **116**, flows into the inside flow passage **118** through the opening, and is drained from the drain port; and the cooling liquid **102** fed from the second feed port, in the passage **112***b*, flows through the outside flow passage **116**, flows into the inside flow passage **118** through the opening, and is drained from the drain port. Therefore, since one common port is formed as the drain port of the cooling liquid **102** flowing through the passage **112***a* and the passage **112***b*, the configuration of the cooling roller **110** is simplified, thereby reducing the cost of the cooling device **18**. Further, it is possible to facilitate routing of the liquid feed tube **155** that connects the drain port with the pump **100**.

Further, according to the present embodiment, a configuration may be employed in which the flow passage wall **117** that is a partition for dividing the inside of the cooling roller **110** into two parts at the middle in the longitudinal direction of the cooling roller is disposed; at one end side of the cooling roller **110**, a first feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a first drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed;

at the other end side of the cooling roller **110**, a second feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a second drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; the cooling liquid **102** fed from the first feed port, in the passage **112***a*, flows through the outside flow passage **116**, is returned by the flow passage wall **117**, flows into the inside flow passage **118** inside the inner tube **115** located at the one end side of the flow passage wall **117**, and is drained from the first drain port; and the cooling liquid **102** fed from the second feed port, in the passage **112***b*, flows through the outside flow passage **116**, is returned by the flow passage wall **117**, flows into the inside flow passage **118** inside the inner tube **115** located at the other end side of the flow passage wall **117**, and is drained from the second drain port. Therefore, since the configuration of the cooling roller **110** is simplified, the cost of the cooling device **18** can be reduced.

Further, according to the present embodiment, positions where the cooling liquids **102** are returned by the flow passage wall **117** in the middle of the passage **112***a* and the passage **112***b* in the longitudinal direction of the cooling roller **110** may be stepwise or continuously changed depending on a position along the circumferential direction of the cooling roller **110**. According to this configuration, it is possible to eliminate a spot in which the cooling liquid does not flow in the outside flow passage **116** over all circumferences of the cooling roller **110** and over the longitudinal direction of the cooling roller **110** in an area of the cooling roller **110** at which the paper P is transported, and thus it is possible to eliminate a spot that can not be locally cooled down.

Further, according to the present embodiment, the rotating tube joint unit **111** that is a support unit for rotatably supporting the outer tube **114** and fixedly supporting the inner tube **115** may be disposed at each end of the cooling roller **110**. According to this configuration, the turbulence is generated in the flow (the flow in the longitudinal direction and the rotation direction) of the cooling liquid **102** inside the outside flow passage **116** near the outer tube **114**, and thus the cooling efficiency can be increased.

Further, according to the present embodiment, the rotating tube joint unit **111** that is a support unit for rotatably supporting the outer tube **114** and the inner tube **115** may be disposed at each end of the cooling roller **110**. According to this configuration, the flow (the flow in the rotation direction and the axial direction) of the cooling liquid **102** inside the outside flow passage **116** becomes smooth, and thus the cooling efficiency can be increased.

Further, according to the present embodiment, the flow passage auxiliary wall **122**, **123**, or **124** that is a guide wall for guiding the cooling liquid **102** from the outside flow passage **116** to the inside flow passage **118** through the opening may be disposed near the opening. According to this configuration, the cooling liquids **102** flowing in through the two different outside flow passages **116** are not directly joined, and the flow is smoothly guided in a direction from the outside flow passage **116** to the inside flow passage **118**. Therefore, it is possible to prevent the cooling efficiency from being lowered.

Further, according to the present embodiment, a plurality of opening may be formed at different positions in the longitudinal direction of the inner tube **115**. According to this configuration, due to the positions in the longitudinal direction of the cooling roller **110** where the openings are formed, positions in which the cooling liquids **102** flowing in from the outside flow passage **116** through the two different outside flow passages **116** collide with each other are changed depending on a position over the all circumferences of the cooling roller **110**. Therefore, it is possible to prevent the cooling efficiency from being locally lowered.

Further, according to the present embodiment, a configuration may be employed in which a center of the width of the paper P in a direction orthogonal to the longitudinal direction of the cooling roller passes through near a position where the cooling liquid **102** flows into the inside flow passage **118** from the outside flow passage **116** in the passage **112***a* and a position where the cooling liquid **102** flows into the inside flow passage **118** from the outside flow passage **116** in the passage **112***b*. According to this configuration, the paper is transported so as to be centered so that the areas of the paper P passing at the two different outside flow passages **116** is equal, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, when the width of the paper P in a direction orthogonal to the longitudinal direction of the cooling roller **110** is smaller than the width of any one of the outside flow passage **116** of the passage **112***a* and the outside flow passage **116** of the passage **112***b* in the longitudinal direction of the cooling roller **110**, the paper P may be transported on the passage **112***a* or the passage **112***b* that has the width, in the longitudinal direction of the cooling roller, larger than the width of the paper P and the cooling liquid **102** may be flowed only in the passage at a side in which the paper P is transported. According to this configuration, the paper P is cooled down by passing the cooling liquid to one of the passage **112***a* and the passage **112***b*, the energy can be saved.

Further, according to the present embodiment, feeding the cooling liquid **102** flowing to the passage **112***a* and the passage **112***b* may be performed by one liquid feed unit. According to this configuration, since the cooling liquid **102** flows to the passage **112***a* and the passage **112***b* by one liquid feed unit, the size of the cooling device can be reduced, and the cost can be reduced. Further, the passage **112***a* and the passage **112***b* may have the same configuration. Thereby, the temperature and the temperature gradient of the cooling roller **110** can become equal left and right in the longitudinal direction of the cooling roller **110**.

Further, according to the present embodiment, the cooling liquid **102** flowing in the passage **112***a* and the cooling liquid **102** flowing in the passage **112***b* may be fed by different liquid feed units. According to this configuration, it is possible to independently control the flow quantity of the passage **112***a* and the quantity of the flow flowing in the passage **112***b*. Further, a liquid feed unit that is low in liquid feed performance, and thus is small in size, and/or low in cost can be used.

Further, according to the present embodiment, the flow quantity adjusting valve **156** may be disposed as the flow quantity adjusting unit for adjusting the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b*, and the flow quantity of the cooling liquid **1** flowing in the passage **112***a* and the flow quantity of the cooling liquid **102** flowing in the passage **112***b* may be equaled by the flow quantity adjusting valve **156**. According to this configuration, control can be performed so that the temperature gradient is symmetrical about a boundary between the passage **112***a* and the passage **112***b* in the longitudinal direction of the cooling roller **110**. Further, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the flow quantity adjusting valve **156** that is the flow quantity adjusting unit for adjusting the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b* and the temperature detecting unit **157** for detecting the temperature of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b* are disposed; and based on the temperature of the cooling liquid **102** detected by the temperature detecting unit **157**, the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the flow quantity of the cooling liquid **102** flowing in the passage **112***b* are adjusted by the flow quantity adjusting valve **156** so that the passage **112***a* and the passage **112***b* have the same cooling efficiency. According to this configuration, control is performed so that the temperature and the temperature gradient of the cooling roller **110** are equal right and left in the longitudinal direction of the cooling roller **110**, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the radiator **154** that is the heat radiating unit for radiating heat of the cooling liquid **102** to the outside, the cooling fan **153** for blowing air to the radiator **154**, the air quantity control unit for controlling the air quantity of the cooling fan **153**, and the temperature detecting unit **157** for detecting the temperature of the cooling liquid flowing in the passage **112***a* and the passage **112***b* are disposed; and based on the temperature of the cooling liquid **102** detected by the temperature detecting unit **157**, the air quantity of the cooling fan **153** is controlled by the air quantity control unit so that the cooling liquid **102** flowing in the passage **112***a* has the same temperature as the cooling liquid **102** flowing in the passage **112***b*. According to this configuration, control is performed so that the temperature and the temperature gradient of the cooling roller **110** are equal right and left in the longitudinal direction of the cooling roller **110**, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the flow quantity adjusting valve **156** that is the flow quantity adjusting unit for adjusting the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b* and the temperature detecting unit **158** for detecting the temperature near the surface of the cooling roller **110** on the passage **112***a* and the passage **112***b* are disposed; and based on the temperature, near the surface of the cooling roller **110**, detected by the temperature detecting unit **158**, the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the flow quantity of the cooling liquid **102** flowing in the passage **112***b* are adjusted by the flow quantity adjusting valve **156** so that the temperature near the surface of the cooling roller **110** on the passage **112***a* is equal to the temperature near the surface of the cooling roller **110** on the passage **112***b*. According to this configuration, since control is performed so that the temperature and the temperature gradient of the cooling roller **110** is equal right and left in the longitudinal direction of the cooling roller **110**, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the radiator **154** that is the heat radiating unit for radiating heat of the cooling liquid **102** to the outside, the cooling fan **153** for blowing air to the radiator **154**, the air quantity control unit for controlling the air quantity of the cooling fan **153**, and the temperature detecting unit **158** for detecting the temperature near the surface of the cooling roller **110** on the passage **112***a* and the passage **112***b* are disposed; and based on the temperature, near the surface of the cooling roller **110**, detected by the temperature detecting unit **158**, the air quantity of the cooling fan **153** is controlled by the air quantity control unit so that the temperature near the surface of the cooling roller **110** on the passage **112***a* is equal to the temperature near the surface of the cooling roller **110** on the passage **112***b*. According to this configuration, since control is performed so that the temperature and the temperature gradient of the cooling roller **110** is equal right and left in the longitudinal direction of the cooling roller **110**, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, in the image forming device that includes the toner image forming unit for forming the toner image on the paper P, the heat fixing unit **16** for fixing the toner image, formed on the paper P, on the paper P by at least heat, and the cooling unit for cooling down the paper P on which the toner image is fixed by the heat fixing unit **16**, the cooling device **18** of the present invention is used as the cooling unit. Thereby, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Third Embodiment

Next, a cooling device according to a third embodiment will be described with reference to FIGS. **42** to **55**. Here, configuration examples of a cooling roller **110** different from the cooling roller **22** of the cooling device **18** according to the first embodiment described above will be described. The cooling device illustrated in FIG. **2** is used as an overall configuration of the cooling device, and duplicated description will be omitted. Further, a configuration example of an image forming device in which the cooing device according to the present embodiment is mounted is the same as that in FIG. **22**, and thus duplicated description is omitted in the present embodiment.

Configuration Example 1

A cooling roller **110** of a configuration example 1 according to a third embodiment is different in flow direction of a cooling medium from that of FIG. **23** according to the second embodiment but is similar in configuration. Therefore, duplicated description will be omitted.

In FIG. **42**, the cooling liquid is fed from the feed port **119***a* of the first rotating joint unit **111***a* to the cooling roller **110**, passes through the inside flow passage **118***a* (the return flow passage) inside the inner tube **115***a*, is returned by the flow passage wall **117**, which separates the flow passage **112***a* and the flow passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***a* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115***a*, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a*.

Similarly, the cooling liquid is fed from the feed port **119***b* of the second rotating joint unit **111***b* to the cooling roller **110**, passes through the inside flow passage **118***b* (the return flow passage) inside the inner tube **115***b*, is returned by the flow passage wall **117**, which separates the flow passage **112***a* and the flow passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***b* (the forward flow passage) that is a space between the outer tube **114** and the inner tube **115***b*, and is drained from the drain port **113***b* of the second rotating tube joint unit **111***b*.

As described above, the cooling roller **110** has the two independent flow passages **112***a* and **112***b* in which reciprocating circulation is performed. The cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and forms the closed-loop flow passage together with the cooling liquid circulating unit which will be described later and is illustrated in FIGS. **52**, **53**, and **54** through the rotating tube joint unit **111***a* and **111***b* to circulate the cooling liquid.

The cooling liquid cooled down by the cooling liquid circulating unit which will be described later and is illustrated in FIGS. **52**, **53**, and **54** is fed from the feed port **119***a* of the first rotating tube joint unit **111***a* to the cooling roller **110** according to the configuration example 1 illustrated in FIG. **42**, passes through the inside flow passage **118***a* (the forward flow passage) inside the inner tube **115***a*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***a* (the first return flow passage) that is the space between the outer tube **114** and the inner tube **115***a*, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a*. At this time, the outer tube **114** at the left side of the flow passage wall **117** is cooled down by the cooling liquid flowing through the outside flow passage **116***a*.

Similarly, the cooling liquid cooled down by the cooling liquid circulating unit which will be described later and is illustrated in FIGS. **53**, **54**, and **55** is fed from the feed port **119***b* of the second rotating tube joint unit **111***b* to the cooling roller **110**, passes through the inside flow passage **118***b* (the forward flow passage) inside the inner tube **115***b*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***b* (the second return flow passage) that is the space between the outer tube **114** and the inner tube **115***b*, and is drained from the drain port **113***b* of the second rotating tube joint unit **111***b*. At this time, the outer tube **114** at the right side of the flow passage wall **117** is cooled down by the cooling liquid flowing through the outside flow passage **116***b*.

Here, at a position where the cooling liquid is returned by the flow passage wall **117** and so flows from the inside flow passage **118***a* or **118***b* to the outside flow passage **116***a* or **116***b*, the temperature of the cooling liquid is low. However, since the paper P heated while passing through the heat fixing unit **16** illustrated in FIG. **1** passes through the surface of the cooling roller **110** while closely contacting the surface of the cooling roller **110**, the temperature of the cooling liquid is more raised as it is closer to the first rotating tube joint unit **111***a* side of the outside flow passage **116***a* and the second rotating tub joint unit **111***b* side of the outside flow passage **116***b*. Therefore, the surface temperature of the cooling roller **110** (the outer tube **114**) is lowest at the flow passage wall **117** side of FIG. **42** and highest at the first rotating tube joint unit **111***a* side and the second rotating tube joint unit **111***b* side.

Therefore, the cooling efficiency is highest near the flow passage wall **117** and lowest at the first rotating tube joint unit **111***a* side and the second rotating tube joint unit **111***b* side in FIG. **42**. The temperature gradient is symmetrical with respect to the flow passage wall **117** of the cooling roller **110** as the boundary, and it is possible to reduce the temperature difference in the width direction of the cooling roller **110**.

Since it is divided into the passage **112***a* (the first return flow passage) and the passage **112***b* (the second return flow passage) by the flow passage wall **117** as the boundary, the outside flow passage **116***a* and the outside flow passage **116***b* absorb heat of the paper P by half. Therefore, it is possible to decrease the temperature increment of the cooling liquid. As a result, the cooling efficiency is increased, and the cooling efficiency difference in the longitudinal direction of the cooling roller **110** is decreased.

Further, since it is possible to efficiently cool down an image central portion of a paper that is generally high in printing rate, it is possible to further prevent the blocking phenomenon of the paper central portion in which heat is likely to be accumulated when the paper is stacked after discharged.

Flow passage auxiliary walls **123***a* and **123***b* described above in FIG. **25** may be formed in the cooling roller **110** illustrated in FIG. **42** so that the cooling liquid can easily flow from the inside flow passage **118** to the outside flow passage **116**.

In the cooling roller **110** illustrated in FIG. **42**, the cooling liquid flowing in through the inside flow passage **118** collides against the flow passage wall **117** and thus is difficult to flow into the outside flow passage **116**, and opposite flow may be generated near the flow passage wall **117**. For this reason, the flow passage auxiliary walls **123***a* and **123***b*, illustrated in FIG. **25**, having an angle for guiding the cooling liquid to flow in a direction from the inside flow passage **118** to the outside flow passage **116** are formed in the flow passage wall **117**. Due to the same reason, even though not shown, the flow passage wall **117** may have a shape with a curvature. Since the flow passage auxiliary walls **123***a* and **123***b* are formed in the flow passage wall **117**, the flow of the cooling liquid from the inside flow passage **118** to the outside flow passage **116** becomes smooth, thereby increasing the cooling efficiency.

Configuration Example 2

Next, a cooling roller **110** according to a configuration example 2 is illustrated in FIGS. **43**A and **43**B. FIG. **43**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the flow passage **112***a* and the flow passage **112***b* are communicated with each other through the flow port **120**. FIG. **43**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **43**A is viewed in a direction of an arrow **X6** in the drawing.

In FIGS. **43**A and **43**B, the cooling liquid is fed from the feed port **119***a* of the first rotating joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***a* (the forward flow passage) inside the inner tube **115**, passes through the outside flow passage **116***a* (the return flow passage) or the outside flow passage **116***b* (the return flow passage) that is the space between the outer tube **114** and the inner tube **115**, passes through the flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of the second rotating tube joint unit **111***b*.

Similarly, the cooling liquid is fed from the feed port **119***b* of the first rotating joint unit **111***b* to the inside of the cooling roller **110**, passes through the inside flow passage **118***b* (the forward flow passage) inside the inner tube **115**, passes through the outside flow passage **116***a* (the return flow passage) or the outside flow passage **116***b* (the return flow passage) that is the space between the outer tube **114** and the inner tube **115**, passes through the flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of the second rotating tube joint unit **111***b*.

As described above, the cooling roller **110** has the two flow passages **112***a* and **112***b* in which the cooling liquid flows through the flow port **120**. The cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and forms the closed-loop flow passage together with the cooling liquid circulating unit which will be described later through the first rotating tube joint unit **111***a* and the second rotating tube joint unit **111***b* to circulate the cooling liquid. Since the inner tube **115** is formed with such a simplified shape, the cost can be reduced.

Depending on the difference in the returning, joining and diverging structure of the flow passage wall **117** and the flow port **120**, the flow method of the cooling liquid may be slightly different, but almost the same cooling effect as the cooling roller **110** of the configuration example 1 is obtained.

Configuration Example 3

Next, a cooling roller **110** according to a configuration example 3 is illustrated in FIGS. **44**A and **44**B. FIG. **44**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, the flow passage **112***a* and the flow passage **112***b* are communicated with each other through the flow port **120**, and the inside flow passage **118** inside the inner tube **115** and the feed port **119** are formed only at any one side of the first rotating tube joint unit **111***a* side and the second rotating tube joint unit **111***b* side. FIG. **44**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **44**A is viewed in a direction of an arrow X7 in the drawing.

In FIGS. **44**A and **44**B, the cooling liquid is fed from the feed port **119***a* of the first rotating joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***a* (the return flow passage) inside the inner tube **115**, passes through the outside flow passage **116***a* (the forward flow passage) or the outside flow passage **116***b* that is the space between an outer tube **114** and an inner tube **115** via the flow port **120** present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of the second rotating tube joint unit **111***b*.

As described above, the cooling roller **110** has the flow passage **112***a* and the passage **112***b* in which the cooling liquid flows through the flow port **120**. The cooling roller **110** has the cooling area divided by the outside flow passage **116***a* and the outside flow passage **116***b* in the longitudinal direction of the cooling roller **110** and forms the closed-loop flow passage together with the cooling liquid circulating unit which will be described later through the first rotating tube joint unit **111***a* and the second rotating tube joint unit **111***b* to circulate the cooling liquid.

Further, the feed port **119** is formed at any one side of the first rotating tube joint unit **111***a* side and the second rotating tube joint unit **111***b* side, and thus it is possible to facilitate routing of a liquid feed tube **155** (see FIG. **53**) of the cooling device **18** which will be described later.

Depending on the difference in the returning and diverging structure of the flow passage wall **117** and the flow port **120**, the flow method of the cooling liquid may be slightly different, but almost the same cooling effect as the cooling rollers **110** of the configuration example 1 and the configuration example 2 is obtained.

Further, as illustrated in FIG. **28**, the flow passage auxiliary wall **124** that guides the cooling liquid flowing in from the inside flow passage **118***a* through the flow port **120** to the outside flow passage **116***a* or the outside flow passage **116***b* may be formed at an end of the inner tube **115***b* at the flow port **120** side. Therefore, it is possible to make the cooling liquid flowing in through the inside flow passage **118***a* to easily flow into the outside flow passage **116***a* or the outside flow passage **116***b* through the flow port **120**.

Configuration Example 4

Next, a cooling roller **110** according to a configuration example 4 is illustrated in FIGS. **45**A and **45**B. FIG. **45**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, the two independent passages **112** are formed, and return positions in the longitudinal direction of the cooling roller **110** are different in the circumferential direction. FIG. **45**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **45**A is viewed from directly above the paper plane.

In FIG. **45**A, the cooling liquid is fed from the feed port **119***a* of the first rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***a* (the forward flow passage) inside the inner tube **115***a*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***a* (the return flow passage) that is the space between the outer tube **114** and the inner tube **115***a*, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a*.

Similarly, the cooling liquid is fed from the feed port **119***b* of the second rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***b* (the forward flow passage) inside the inner tube **115***b*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***b* (the return flow passage) that is the space between the outer tube **114** and the inner tube **115***b*, and is drained from the drain port **113***b* of the second rotating tube joint unit **111***b*.

Here, in order to eliminate a spot that can not be cooled locally over one round in a circumferential direction since the cooling liquid is not passed to the outside flow passage **116**, the flow passage wall **117** is disposed obliquely with respect to the longitudinal direction of the cooling roller **110**. The inner tube **115***a* and the inner tube **115***b* have oblique cross sections so that the return positions can be different in the circumferential direction and disposed alternately in the longitudinal direction of the cooling roller **110**.

In the present configuration example, at a circumferential direction position C**1** of the cooling roller **110** illustrated in FIG. **46**A, the cooling roller **110** is cooled down by the cooling liquid flowing through the outside flow passage **116***a* (the first return flow passage). As the cooling roller **110** rotates, at a circumferential direction position C**2** of the cooling roller **110**, the cooling roller **110** is cooled down by the cooling liquid flowing through the outside flow passage **116***b* (the second return flow passage). Therefore, since it is possible to eliminate a spot in which the cooling liquid is not circulated in the outside flow passages **116**a and **116**b over one round in the circumferential direction of the cooling roller **110** near a position where the cooling liquid is returned by the flow passage wall **117**, it is possible to eliminate a spot where the cooling efficiency is locally lowered.

In the example illustrated in FIG. **45**B, the inner tubes **115**a and **115**b have the oblique cross sections. However, the cross sections of the inner tubes **115**a and **115**b are not limited to the oblique structure but may have a structure in which the cooling liquid does not locally flow to the outside flow passage **116** over one round in the circumferential direction of the cooling roller **110** and does not disturb the flow of the cooling liquid.

As described above, the cooling roller **110** has the two independent flow passages **112**a and **112**b in which reciprocating circulation is performed. The cooling roller **110** has the cooling area divided in the longitudinal direction of the cooling roller **110** and forms the closed-loop flow passage together with the cooling liquid circulating unit which will be described later through the first rotating tube joint unit **111**a and the second rotating tube joint unit **111**b to circulate the cooling liquid.

Configuration Example 5

Next, a cooling roller **110** according to a configuration example 5 is illustrated in FIGS. **46**A and **46**B. FIG. **46**A is a schematic cross-sectional view of a cooling roller **110** in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the two independent flow passages **112**a and **112**b are formed. FIG. **46**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **46**A is viewed in a direction of an arrow X**10** in the drawing.

The outer tube **114** rotates. One end side of the inner tube **115**a is fixedly supported to the first rotating tube joint unit **111**a not to rotate, and the other end side is rotatably supported to the flow passage wall **117** through a bearing (not shown). One end side of the inner tube **115**b is fixedly supported to the second rotating tube joint unit **111**b not to rotate, and the other end side is rotatably supported to the flow passage wall **117** through a bearing (not shown). The flow port **120**a is formed in the inner tube **115**a near the flow passage wall **117** to allow the cooling liquid to flow from the inside flow passage **118**a to the outside flow passage **16**a. The flow port **120**b is formed in the inner tube **115**b near the flow passage wall **117** to allow the cooling liquid to flow from the inside flow passage **118**b to the outside flow passage **116**b.

The cooling roller **110** having such a configuration generates the turbulence in the flow (the flow in the axial direction and the rotation direction) of the cooling liquid inside the outside flow passage **116**, particularly, near the inside of the outer tube **114**, thereby increasing the cooling efficiency.

Configuration Example 6

Next, a cooling roller **110** according to a configuration example 6 is illustrated in FIGS. **47**A and **47**B. FIG. **47**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the two passages **112**a and **112**b are communicated with each other through the flow port **120**. The outer tube **114** rotates, and both ends of the inner tube **115** are rotatably supported to the rotating tube joint unit **111**. FIG. **47**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **47**A is viewed in a direction of an arrow X**11** in the drawing.

In the present configuration example, similarly to the embodiment illustrated in FIGS. **31**A, **31**B and **32**, the outer tube **114** and the inner tube **115** are locally fixed by the coupling support unit **121**. Therefore, the outer tube **114** and the inner tube **115** rotate together. Preferably, the coupling support unit **121** has a mechanical strength that can endure the load generated when the outer tube **114** and the inner tube **115** rotate together and has a structure that disturbs the flow of the cooling liquid flowing through the outside flow passage **116** as little as possible.

The cooling roller **110** having such a configuration makes smooth the flow (the flow in the axial direction and the rotation direction) of the cooling liquid inside the outside flow passage **116**, thereby increasing the cooling efficiency.

Configuration Example 7

Next, a cooling roller **110** according to a configuration example 7 is illustrated in FIGS. **48**A and **48**B. FIG. **48**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the two passages **112**a and **112**b are communicated with each other through the flow port **120**. FIG. **48**B is an enlarged view of the inner tube **115** when the cooling roller **110** illustrated in FIG. **48**A is viewed in a direction of an arrow X13 in the drawing.

The flow passage auxiliary wall **122** is fixed to the inner wall of the outer tube **114** between a spot of the inner tube **115** where the flow port **120** is formed and the outer tube **114**. The cooling liquids flowing in through the inside flow passages **118**a and **118**b easily flows into the outside flow passages **116**a and **116**b through the flow port **120**.

When the inner tube **115** does not rotate or when the inner tube **115** rotate together with the outer tube **114**, the flow passage auxiliary wall **122** can be formed to extend up to the inside of the flow port **120**. However, when the outer tube **114** and the inner tube **115** asynchronously rotate, the flow passage auxiliary wall **122** needs to be disposed inside the outside flow passage **116** not to come into contact with the inner tube **115**.

Further, as described in the embodiment illustrated in FIG. **34**, even when the inner tube **115** is divided into the inner tube **115**a and the inner tube **115**b, the flow passage auxiliary wall **122** may be disposed to be fixed to the inner wall of the outer tube **114** near the passages **112**a and **112**b. Therefore, it is possible to enable the cooling liquid flowing in through the inside flow passages **118**a and **118**b to easily flow into the outside flow passages **116**a and **116**b through the passages **112**a and **112**b.

Configuration Example 8

Next, a cooling roller **110** according to a configuration example 8 is illustrated in FIGS. **49**A and **49**B. FIG. **49**A is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the two passages **112**a and **112**b are communicated with each other through the flow port **120**. FIG. **49**B is a cross-sectional view when the cooling roller **110** illustrated in FIG. **49**A is viewed in a direction of an arrow X**15** in the drawing.

In the present configuration example, at least two flow ports **120**a and **120**b that allow the outside flow passage **116** and the inside flow passage **118** to communicate with each other are formed in the inner tube **115**. Positions where the cooling liquids are returned in the longitudinal direction of the cooling roller **110** are different in the circumferential direction. Therefore, it is possible to prevent all of the cooling liquids from flowing from the inside flow passage **118** to the outside flow passage **116** at the same position of the longitudinal direction of the cooling roller **110** over one round in the circumferential direction.

At a circumferential direction position C**2** of the cooling roller **110** of FIG. **49**A, the cooling liquid is fed from the feed port **119***a* of the first rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***a* inside the inner tube **115**, passes through the outside flow passage **116***a* and the outside flow passage **116***b* that are the spaces between the outer tube **114** and the inner tube **115** via the flow port **120***a* present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of a second rotating tube joint unit **111***b*.

Similarly, the cooling liquid is fed from the feed port **119***b* of the second rotating tube joint unit **111***b* to the inside of the cooling roller **110**, passes through the inside flow passage **118***b* inside the inner tube **115**, passes through the outside flow passage **16***a* and the outside flow passage **116***b* that are the spaces between the outer tube **114** and the inner tube **115** via the flow port **120***a* present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of a second rotating tube joint unit **111***b*.

At a circumferential direction position C**1** of the cooling roller **110** of FIG. **49**A, the cooling liquid is fed from the feed port **119***a* of the first rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***a* inside the inner tube **115**, passes through the outside flow passage **116***a* and the outside flow passage **116***b* that are the spaces between the outer tube **114** and the inner tube **115** via the flow port **120***b* present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of a second rotating tube joint unit **111***b*.

Similarly, the cooling liquid is fed from the feed port **119***b* of the first rotating tube joint unit **111***b* to the inside of the cooling roller **110**, passes through an inside flow passage **118***b* inside the inner tube **115**, passes through the outside flow passage **116***a* and the outside flow passage **116***b* that are the spaces between the outer tube **114** and the inner tube **115** via the flow port **120***b* present in the middle in the longitudinal direction of the cooling roller **110**, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of a second rotating tube joint unit **111***b*.

As described above, a plurality of flow ports formed in the inner tube **115** are disposed at different positions in the circumferential direction of the cooling roller **110**. When the cooling liquids flowing in through the outside flow passages **116** at different positions in the circumferential direction flow into the inside flow passage **118**, the cooling liquids flowing into the inside flow passage **118** from the different flow ports **120** do not collide with each other. Therefore, opposite flow or the turbulence can be reduced, and the flow of the cooling liquid from the outside flow passage **116** to the inside flow passage **118** becomes smooth, thereby increasing the cooling efficiency. Therefore, since opposite flow or the turbulence can be reduced, it is possible to prevent the cooling efficiency from being locally lowered.

Configuration Example 9

Next, a cooling roller **110** according to a configuration example 9 is illustrated in FIG. **50**. FIG. **50** is a schematic cross-sectional view of a cooling roller **110** having a structure in which the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, and the passage **112***a* and the passage **112***b* are communicated with each other through the flow port **120**. The paper P that became a high temperature while passing through the heat fixing unit **16** (see FIG. **2**) is transported in a direction orthogonal to the longitudinal direction of the cooling roller **110**.

In FIG. **50**, the cooling liquid is fed from the feed port **119***a* of the first rotating tube joint unit **111***a* to the inside of the cooling roller **110**, passes through the inside flow passage **118***a* inside the inner tube **115***a*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***a* that is the space between the outer tube **114** and the inner tube **115***a*, and is drained from the drain port **113***a* of the first rotating tube joint unit **111***a*.

Similarly, the cooling liquid is fed from the feed port **119***b* of the second rotating tube joint unit **111***b* to the inside of the cooling roller **110**, passes through the inside flow passage **118***b* inside the inner tube **115***b*, is returned by the flow passage wall **117**, which separates the passage **112***a* and the passage **112***b*, present in the middle in the longitudinal direction of the cooling roller **110**, passes through the outside flow passage **116***b* that is the space between the outer tube **114** and the inner tube **115***b*, and is drained from the drain port **113***b* of the second rotating tube joint unit **111***b*.

Therefore, if heat is not received from the outside except the paper P, the temperature of the cooling liquid flowing through the outside flow passage **116** of the cooling roller **110** and the surface temperature of the outer tube **114** of the cooling roller **110** are lowest at a position where the cooling liquid is retuned in the inside flow passages **118***a* and **118***b* and flows into the outside flow passages **116***a* and **116***b* and are highest at the first rotating tube joint unit **111***a* side or the second rotating tube joint unit **111***b* side.

For this reason, in the present configuration example, the paper P is transported in the longitudinal direction of the cooling roller **110** so that a central position of the paper P can pass through a position of the flow passage wall **117**. As a result, the outer tube **114** of the cooling roller **110** is cooled down with a temperature gradient that becomes equal left and right in the width direction of the paper P, and the passages **112***a* and **112***b* are deprived of the same heat quantity. Therefore, it is possible to prevent the temperature of the cooling liquid from being greatly increased in any one of the passages **112**.

Further, since the outer tube **114** of the cooling roller **110** is cooled down with the temperature gradient that is equal left and right in the width direction of the paper P, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, when the cooling roller of a structure that does not have the flow passage wall **117** formed in the cooling roller **110** is used in the present configuration example, the paper P is preferably transported in the longitudinal direction of the cooling roller **110** so that the central position of the paper P can pass through the central position of the flow port **120**.

Here, if the width of the paper P is smaller than the length of the outside flow passage **116***a*, the cooling liquid is passed only to the passage **112***a*, and the paper P is transported on the passage **112***a* of the cooling roller **110** as illustrated in FIG.

51. As described above, the paper P is cooled down by passing the cooling liquid only to one flow passage **112***a*, thereby saving the energy and increasing the lift span of the cooling device **18**.

In FIG. **51**, the outside flow passage **116***a* is identical in length to the outside flow passage **116***b*. However, the outside flow passage **116***a* may be different in length from the outside flow passage **116***b*. In this case, the width of the paper P is detected. If the width of the paper P is smaller than both of the length of the outside flow passage **116***a* and the length of the outside flow passage **116***b*, the paper P can be transported on either of the outside flow passage **116***a* and the outside flow passage **116***b*. However, if the width of the paper P is larger than one of the length of the outside flow passage **116***a* and the length of the outside flow passage **116***b* and smaller than the other, the paper P is preferably transported on the outside flow passage **116***a* or the outside flow passage **116***b* that has the length larger than the width of the paper P.

Next, a case where the cooling liquid **102** is fed through one feed unit will be described with reference to FIG. **52**.

In the cooling circulation device **150**, illustrated in FIG. **52**, used in the cooling device **18**, the cooling liquid **102** inside the tank **101** is fed by the pump **100**, and when passing through a radiator **154** that is a heat radiation unit, the cooling fan **153** blows air to radiate heat to the outside, thereby lowering the temperature of the cooling liquid **102** (heat exchange between the cooling liquid **102** and the outside). The cooling liquid **102** cooled down by the radiator **154** is fed to the inside of the cooling roller **110** from the feed port **119***a* of the first rotating tube joint unit **111***a* and the feed port **119***b* of the second rotating tube joint unit **111***b*, which are mounted to both axial direction ends of the cooling roller **110**, through the feed tube **155** in which the flow passage is divided into two parts at a diverging point J**1**, and flows through the passage **112***a* or the passage **112***b* inside the cooling roller **110**. At this time, the cooling roller **110** deprives the paper P, which became a high temperature while passing through the heat fixing unit **16**, of heat, so that the temperature of the cooling liquid **102** inside the cooling roller **110** is raised (heat exchange between the cooling liquid **102** and the paper P). The cooling liquid **102** that was raised in temperature inside the cooling roller **110** is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* or the drain port **113***b* of the second rotating tube joint unit **111***b*, passes through the liquid feed tube **155** that is joined into one flow passage at a joining point J**2**, and is fed again by the pump **100** via the tank **101**. Through the circulation of the cooling liquid **102**, radiating heat of the paper P to the outside of the cooling device **18** is repeated.

In the cooling circulation device **150** illustrated in FIG. **52**, if the flow passage to the cooling roller **110** from after going out of the radiator **154** and the flow passages of the passage **112***a* side and the passage **112***b* side of the cooling roller **110** are the same in structure, feeding can be performed by one pump **100**, so that the feed port **119***a* and the feed port **119***b* have the same flow quantity and pressure. Therefore, the cooling roller **110** can have the cooling efficiency that is symmetrical at the left side and the right side of the flow passage wall **117**.

Next, a case where the cooling liquid **102** is fed through two feed unit will be described with reference to FIG. **53**.

In the cooling circulation device **150** illustrated in FIG. **53**, circulation systems of the cooling liquid **102** the passage **112***a* and the passage **112***b* of the cooling roller **110** have a flow passage R**1** and a flow passage R**2** which are independent of each other.

At the flow passage R**1** side, the cooling liquid **102***a* inside the tank **101***a* is fed by the pump **100***a*, and when passing through the radiator **154***a*, the cooling fan **153***a* blows air to radiate heat to the outside, thereby lowering the temperature of the cooling liquid **101** (heat exchange between the cooling liquid **102***a* and the outside). The cooling liquid **102***a* cooled down by the radiator **154***a* is fed to the inside of the cooling roller **110** from the feed port **119***a* of the first rotating tube joint unit **111***a*, which is mounted to an axial direction one end of the cooling roller **110**, through the feed tube **155***a*, and flows through the passage **112***a* inside the cooling roller **110**. At this time, the cooling roller **110** deprives the paper P, which became a high temperature while passing through the heat fixing unit **16**, of heat, so that the temperature of the cooling liquid **102***a* inside the cooling roller **110** is raised (heat exchange between the cooling liquid **102***a* and the paper P). The cooling liquid **102** that was raised in temperature inside the cooling roller **110** is drained from the drain port **113***a* of the first rotating tube joint unit **111***a* and is fed again by the pump **100***a* via the tank **101***a*.

Further, at the flow passage R**2** side, the cooling liquid **102***b* inside the tank **101***b* is fed by the pump **100***b*, and when passing through a radiator **154***b*, the cooling fan **153***b* blows air to radiate heat to the outside, thereby lowering the temperature of the cooling liquid **102***b* (heat exchange between the cooling liquid **102***b* and the outside). The cooling liquid **102***b* cooled down by the radiator **154***b* is fed to the inside of the cooling roller **110** from the feed port **119***b* of the second rotating tube joint unit **111***b*, which is mounted to an axial direction one end of the cooling roller **110**, through the feed tube **155***b*, and flows through the passage **112***b* inside the cooling roller **110**. At this time, the cooling roller **110** deprives the paper P, which became a high temperature through the heat fixing unit **16**, of heat, so that the temperature of the cooling liquid **102***b* inside the cooling roller **110** is raised (heat exchange between the cooling liquid **102***b* and the paper P). The cooling liquid **102** that was raised in temperature inside the cooling roller **110** is drained from the drain port **113***b* of the second rotating tube joint unit **111***b* and is fed again by the pump **100***b* via the tank **101***b*.

Therefore, when the passage **112***a* and the passage **112***b* inside the cooling roller **110** are different, when the passage **112***a* and the passage **112***b* of the cooling roller **110** are different in heat quantity received from the outside, or when the flow passages to the cooling roller **110** from after going out of the radiators **154***a* and **154***b* are different, it possible to independently control the feed liquid quantities of the pumps **152***a* and **152***b*, the air quantities of the cooling fans **153***a* and **153***b*, and the flow quantities of the cooling liquids **102***a* and **102***b*.

Next, a mechanism of adjusting the flow quantity of the cooling liquid **102** will be described.

When the cooling circulation device **150** is mounted in the image forming device, even though the flow passage to the cooling roller **110** from after going out of the radiator **154** and the flow passages of the passage **112***a* side and the passage **112***b* side of the cooling roller **110** are the same in structure, due to layout and spatial problems, the liquid feed tube **155** connected to the first rotating tube joint unit **111***a* may be different in length from the liquid feed tube **155** connected with the second rotating tube joint unit **111***b*. At this time, due to influence of pressure loss, the two passages inside the cooling roller **110**, that is, the passage **112***a* and the passage **112***b* have different cooling efficiencies. Further, in addition to the configuration difference of a circulation system, a variation of the component accuracy or a variation between lots may occur. For these reasons, the flow quantity adjusting valve **156** is connected to the liquid feed tube **155** of the cooling circulation device **150**, and thus the flow quantity can be adjusted by a mechanical mechanism.

Next, a case of detecting the temperature of the cooling liquid **102** to control the flow quantity of the cooling liquid **102** will be described. FIG. **54** illustrates an example in which temperature detecting unit **157***a* and **157***b* that detect the temperature of the cooling liquid **102** are disposed inside the tanks **101***a* and **101***b*.

The temperatures of the cooling liquids **102** detected by the temperature detecting unit **157***a* and **157***b* are feedback controlled. The flow quantity of the cooling liquid **102** is adjusted by adjusting the feed liquid quantities of the pumps **100***a* and **100***b* or the flow quantity adjusting valves **156***a* and **156***b* so that the cooling liquid **102** flowing through the passage **112***a* of the cooling roller **110** can have the same temperature as the cooling liquid flowing through the passage **112***b*.

Here, since a cooling target is the paper P transported on the cooling roller **110**, a method of detecting the temperatures of the cooling liquids **102** flowing through the outside flow passages **116***a* and **116***b* inside the cooling roller **110** through the temperature detecting unit **157***a* and **157***b* and performing feedback control has the highest degree of accuracy. However, the outside flow passages **116***a* and **116***b* inside the cooling roller **110** have a problem on the space for disposing the temperature detecting units **157***a* and **157***b* or a problem in that the cooling roller **110** is rotary-driven. For this reason, as positions for actually forming the temperature detecting units **157***a* and **157***b*, positions where temperature detecting units **157***c* and **157***d* illustrated in FIG. **54** are disposed directly before the cooling liquids **102** flow into the feed port **119***a* of the first rotating tube joint unit **111***a* and the feed port **119***b* of the second rotating tube joint unit **111***b* are preferable. Further, a configuration of feeding back the temperature of the cooling liquid **102** detected by each temperature detecting unit **157** and controlling the air quantities of the cooling fans **153***a* and **153***b* to control the temperature of the cooling liquid **102** is possible.

In the present embodiment, it is also possible to control the flow quantity of the cooling liquid **102** by detecting the temperature near the surface of the cooling roller **110**.

The temperature near the surface of the cooling roller **110** detected by the temperature detecting unit **158** is feedback controlled. The flow quantity of the cooling liquid **102** is adjusted, for example, by adjusting the feed liquid quantity of the pump **100** or the flow quantity adjusting valves **156***a* and **156***b* illustrated in FIG. **52** so that the cooling liquid flowing through the passage **112***a* of the cooling roller **110** can have the same temperature as the cooling liquid flowing through the passage **112***b*. Further, the temperature of the cooling liquid is controlled by feeding back the temperature near the surface of the cooling roller **110** of the cooling roller **110** detected by the temperature detecting unit **158** and controlling the air quantity of the cooling fan **153** of FIG. **52**.

In the present embodiment, the rotating tube joint unit **111** are mounted to both axial direction ends of the cooling roller **110**, but as illustrated in FIG. **55**, a configuration in which the rotating tube joint unit **111** is mounted only to one end side of the cooling roller **110** is possible. In this case, the inside of the inner tube **115** disposed inside the outer tube **114** partially has the dual tube structure. The cooling liquid **102** fed from the feed port **119** of the rotating tube joint unit **111** flows through the inside flow passage **118***a* inside the inner tube **115** from one end side, which is a side at which the rotating tube joint unit **111** of the cooling roller is mounted, toward the other end side, passes through the communication port **120** formed in a central portion of the inner tube **115**, is diverged by a diverging wall **125**, and flows into the outside flow passage **116***a* and the outside flow passage **116***b*. The cooling liquid **102** flowing into the outside flow passage **116***a* flows through the outside flow passage **116***a* toward the one end side and is drained from the drain port **113** of the rotating tube joint unit ill. Meanwhile, the cooling liquid **102** flowing into the outside flow passage **116***b* flows through the outside flow passage **116***b* toward the other end side, is returned by the inside cross section of the outer tube **114** at the other end side, and flows into the inside flow passage **118***b* inside the inner tube **115**. The cooling liquid **102** flowing into the inside flow passage **118** flows toward the one end side, passes through the inside flow passage **118***c* of the inner tube **115**, and is drained from the drain port **113** of the rotating tube joint unit **111**.

As described above, according to the present embodiment, the cooling device **18** includes the cooling roller **110** for contacting the paper P as the sheet-like member to cool the paper P and the pump **100** that is a cooling medium feeding/retrieving unit for feeding the cooling liquid **102** as the cooling medium to the inside of the cooling roller **110** from the feed port disposed in the cooling roller **110** and retrieving the cooling liquid **102** drained to the outside of the cooling roller **110** from the drain port disposed in the cooling roller **110**. The cooling roller **110** has a dual tube structure in which the inner tube **115** is disposed inside the outer tube **114**, and the outside flow passage **116** in which the cooling liquid **102** flows through the space between the outer tube **114** and the inner tube **115** and the inside flow passage **118** in which the cooling liquids **102** flows inside the inner tube **115** are formed. An opening that allows the outside flow passage **116** and the inside flow passage **118** to communicate with each other is formed in the middle of the inner tube **115** in the longitudinal direction of the cooling roller **110**. The passage **112***a* as a first passage in which the cooling liquid **102** fed by the pump **100** flows the inside flow passage **118**, flows into the outside flow passage **116** via the opening, and flows toward at least one end side of the cooling roller **110** and the passage **112***b* as a second passage in which the cooling liquid **102** fed by the pump **100** flows through the inside flow passage **118**, flows into the outside flow passage **116** via the opening, and flows toward at least the other end side of the cooling roller **110** are formed. According to this configuration, the passage in which the cooling liquid **102** flows is divided into two parts in the longitudinal direction of the cooling roller **110** to cool down the cooling roller **110**. Therefore, compared to the configuration in which the cooling liquid **102** flows in one direction in the longitudinal direction of the cooling roller **110**, the temperature increment of the cooling roller **110** can be further reduced. Further, the temperature difference in the longitudinal direction and the temperature difference between both ends of the cooling roller **110** can be reduced. Further, uniform image quality and gloss can be obtained in the width direction of the cooling roller **110**. Further, the temperature control may be performed symmetrically in the longitudinal direction of the cooling roller **110**, and thus the curl of the paper P can be reduced.

Further, according to the present embodiment, a configuration may be employed in which the opening is formed in a central portion of the inner tube **115** in the longitudinal direction of the cooling roller; at one end side of the cooling roller **110**, a first feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a first drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; at the other end side of the cooling roller **110**, a second feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a second drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; the cooling liquid **102** fed from the first feed port, in the passage **112***a*, flows through the inside flow passage **118**, flows into the outside flow passage **116** through the opening, flows toward at least one of the one end side and the other end side, and is drained from at least one of the first drain port and the second drain port; and the cooling liquid **102** fed from the second feed port, in the passage **112***b*, flows through the inside flow passage **118**, flows into the outside flow passage **116** through the opening, flows toward at least one of the one end side and the other end side, and is drained from at least one of the first drain port and the second drain port. According to this configuration, since the configuration of the cooling roller **110** is simplified, the cost of the cooling device **18** can be reduced.

Further, according to the present embodiment, a configuration may be employed in which the opening is formed in a central portion of the inner tube **115** in the longitudinal direction of the cooling roller **110**; at one end side of the cooling roller **110**, a first feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** is formed; at the other end side of the cooling roller **110**, a second feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** is formed; a drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** is formed at any of one end side and the other end side of the cooling roller **110**; the cooling liquid **102** fed from the first feed port, in the passage **112***a*, flows through the inside flow passage **118**, flows into the outside flow passage **116** through the opening, flows toward at least one of the one end side and the other end side, and is drained from the drain port; and the cooling liquid **102** fed from the second feed port, in the passage **112***b*, flows through the inside flow passage **118**, flows into the outside flow passage **116** through the opening, flows toward at least one of the one end side and the other end side, and is drained from the drain port. According to this configuration, since one common port is formed as the drain port of the cooling liquid **102** flowing through the passage **112***a* and the passage **112***b*, the configuration of the cooling roller **110** is simplified, thereby reducing the cost of the cooling device **18**. Further, it is possible to facilitate routing of the liquid feed tube **155** that connects the drain port with the pump **100**.

Further, according to the present embodiment, a configuration may be employed in which the flow passage wall **117** that is a partition for dividing the inside of the cooling roller **110** into two parts is disposed in the middle in the longitudinal direction of the cooling roller; at one end side of the cooling roller **110**, a first feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a first drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; at the other end side of the cooling roller **110**, a second feed port for feeding the cooling liquid **102** to the inside of the cooling roller **110** and a second drain port for draining the cooling liquid **102** from the inside of the cooling roller **110** to the outside of the cooling roller **110** are formed; the cooling liquid **102** fed from the first feed port, in the passage **112***a*, flows through the inside flow passage **118**, is returned by the flow passage wall **117**, flows into the outside flow passage **116** located at the one end side of the flow passage wall **117**, and is drained from the first drain port; the cooling liquid **102** fed from the second feed port, in the passage **112***b*, flows through the inside flow passage **118**, is returned by the flow passage wall **117**, flows into the outside flow passage **116** located at the other end side of the flow passage wall **117**, and is drained from the second drain port. According to this configuration, since the configuration of the cooling roller **110** is simplified, the cost of the cooling device **18** can be reduced.

Further, according to the present embodiment, positions where the cooling liquids **102** are returned by the flow passage wall **117** in the middle of the passage **112***a* and the passage **112***b* in the longitudinal direction of the cooling roller **110** may be stepwise or continuously changed depending on a position along the circumferential direction of the cooling roller **110**. According to this configuration, it is possible to eliminate a spot in which the cooling liquid does not flow in the outside flow passage **116** over all circumferences of the cooling roller **110** and over the longitudinal direction of the cooling roller **110** in an area of the cooling roller **110** at which the paper P is transported, and thus it is possible to eliminate a spot that can not be locally cooled down.

Further, according to the present embodiment, the rotating tube joint unit **111** that is a support unit for rotatably supporting the outer tube **114** and fixedly supporting the inner tube **115** may be disposed at each end of the cooling roller **110**. According to this configuration, the turbulence is generated in the flow (the flow in the longitudinal direction and the rotation direction) of the cooling liquid **102** inside the outside flow passage **116** near the outer tube **114**, and thus the cooling efficiency can be increased.

Further, according to the present embodiment, the rotating tube joint unit **111** that is a support unit for rotatably supporting the outer tube **114** and the inner tube **115** may be disposed at each end of the cooling roller **110**. According to this configuration, the flow (the flow in the rotation direction and the axial direction) of the cooling liquid **102** inside the outside flow passage **116** becomes smooth, and thus the cooling efficiency can be increased.

Further, according to the present embodiment, the flow passage auxiliary wall **122**, **123**, or **124** may be disposed near the opening as the guide wall for guiding the cooling liquid **102** from the inside flow passage **118** to the outside flow passage **116** through the opening. According to this configuration, the cooling liquids **102** flowing in through the two different inside flow passages **118** are not directly joined, and thus the flow can be smoothly guided in a direction from the inside flow passage **118** to the outside flow passage **116**. Therefore, it is possible to prevent the cooling efficiency from being lowered.

Further, according to the present embodiment, a plurality of opening may be formed at different positions in the longitudinal direction of the inner tube **115**. According to this configuration, due to the positions where the openings are present in the longitudinal direction of the cooling roller **110**, positions in which the cooling liquids **102** flowing in from the outside flow passage **116** through the two different outside flow passages **116** collide with each other are changed depending on a position over the all circumferences of the cooling roller **110**. Therefore, it is possible to prevent the cooling efficiency from being locally lowered.

Further, according to the present embodiment, a configuration may be employed in which a center of the width of the paper P in a direction orthogonal to the longitudinal direction of the cooling roller passes through near a position where the cooling liquid **102** flows into the inside flow passage **118** from the outside flow passage **116** in the passage **112***a* and a position where the cooling liquid **102** flows into the inside flow passage **118** from the outside flow passage **116** in the passage **112***b*. According to this configuration, the paper is transported so as to be centered so that the areas of the paper P passing at the two different outside flow passages **116** is equal, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, when the width of the paper P in a direction orthogonal to the longitudinal direction of the cooling roller **110** is smaller than the width of any one of the outside flow passage **116** of the passage **112***a* and the outside flow passage **116** of the passage **112***b* in the longitudinal direction of the cooling roller **110**, the paper P may be transported on the passage **112***a* or the passage **112***b* that has the width, in the longitudinal direction of the cooling roller, larger than the width of the paper P and the cooling liquid **102** may be flowed only in the passage at a side in which the paper P is transported. According to this configuration, since the paper P is cooled down by passing the cooling liquid to one of the passage **112***a* and the passage **112***b*, the energy can be saved.

Further, according to the present embodiment, feeding the cooling liquid **102** flowing to the passage **112***a* and the passage **112***b* may be performed by one liquid feed unit. According to this configuration, since the cooling liquid **102** flows to the passage **112***a* and the passage **112***b* by one liquid feed unit, the size of the cooling device can be reduced, and the cost can be reduced. The passage **112***a* and the passage **112***b* may have the same configuration. Thereby, the temperature and the temperature gradient of the cooling roller **110** can become equal left and right in the longitudinal direction of the cooling roller **110**.

Further, according to the present embodiment, the cooling liquid **102** flowing in the passage **112***a* and the cooling liquid **102** flowing in the passage **112***b* may be fed by different liquid feed units. According to this configuration, it is possible to independently control the quantity of the flow flowing in the passage **112***a* and the quantity of the flow flowing in the passage **112***b*. Further, a liquid feed unit that is low in liquid feed performance, small in size, and low in cost can be used.

Further, according to the present embodiment, the flow quantity adjusting valve **156** may be disposed as the flow quantity adjusting unit for adjusting the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b*, and the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the flow quantity of the cooling liquid **102** flowing in the passage **112***b* may be equaled by the flow quantity adjusting valve **156**. According to this configuration, control can be performed so that the temperature gradient can be symmetrical about a boundary between the passage **112***a* and the passage **112***b* in the longitudinal direction of the cooling roller **110**. Further, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the flow quantity adjusting valve **156** that is the flow quantity adjusting unit for adjusting the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b* and the temperature detecting unit **157** for detecting the temperature of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b* are disposed; and based on the temperature of the cooling liquid **102** detected by the temperature detecting unit **157**, the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the flow quantity of the cooling liquid **102** flowing in the passage **112***b* are adjusted by the flow quantity adjusting valve **156** so that the passage **112***a* and the passage **112***b* can have the same cooling efficiency. According to this configuration, control is performed so that the temperature and the temperature gradient of the cooling roller **110** are equal right and left in the longitudinal direction of the cooling roller **110**, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the radiator **154** that is the heat radiating unit for radiating heat of the cooling liquid **102** to the outside, the cooling fan **153** for blowing air to the radiator **154**, the air quantity control unit for controlling the air quantity of the cooling fan **153**, and the temperature detecting unit **157** for detecting the temperature of the cooling liquid flowing in the passage **112***a* and the passage **112***b* are disposed, and based on the temperature of the cooling liquid **102** detected by the temperature detecting unit **157**, the air quantity of the cooling fan **153** is controlled by the air quantity control unit so that the cooling liquid **102** flowing in the passage **112***a* has the same temperature as the cooling liquid **102** flowing in the passage **112***b*. According to this configuration, control is performed so that the temperature and the temperature gradient of the cooling roller **110** are equal right and left in the longitudinal direction of the cooling roller **110**, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the flow quantity adjusting valve **156** that is the flow quantity adjusting unit for adjusting the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the passage **112***b* and the temperature detecting unit **158** for detecting the temperature near the surface of the cooling roller **110** on the passage **112***a* and the passage **112***b* are disposed; and based on the temperature, near the surface of the cooling roller **110**, detected by the temperature detecting unit **158**, the flow quantity of the cooling liquid **102** flowing in the passage **112***a* and the flow quantity of the cooling liquid **102** flowing in the passage **112***b* are adjusted by the flow quantity adjusting valve **156** so that the temperature near the surface of the cooling roller **110** on the passage **112***a* is equal to the temperature near the surface of the cooling roller **110** on the passage **112***b*. According to this configuration, control is performed so that the temperature and the temperature gradient of the cooling roller **110** are equal right and left in the longitudinal direction of the cooling roller **110**, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, a configuration may be employed in which the radiator **154** that is the heat radiating unit for radiating heat of the cooling liquid **102** to the outside, the cooling fan **153** for blowing air to the radiator **154**, the air quantity control unit for controlling the air quantity of the cooling fan **153**, and the temperature detecting unit **158** for detecting the temperature near the surface of the cooling roller **110** on the passage **112***a* and the passage **112***b* are disposed; and based on the temperature, near the surface of the cooling roller **110**, detected by the temperature detecting unit **158**, the air quantity of the cooling fan **153** is controlled by the air quantity control unit so that the temperature near the surface of the cooling roller **110** on the passage **112***a* is equal to the temperature near the surface of the cooling roller **110** on the passage **112***b*. According to this configuration, control is performed so that the temperature and the temperature gradient of the cooling roller **110** is equal right and left in the longitudinal direction of the cooling roller **110**, and thus it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

Further, according to the present embodiment, in the image forming device that includes the toner image forming unit for forming the toner image on the paper P, the heat fixing unit **7** for fixing the toner image, formed on the paper P, on the paper

P by at least heat, and the cooling unit for cooling down the paper P on which the toner image is fixed by the heat fixing unit **7**, the cooling device **18** of the present invention is used as the cooling unit. Thereby, it is possible to reduce curl, and image quality and gloss unevenness caused by fixing in the width direction of the paper P.

As described above, according to the present invention, an excellent effect of being capable of improving the cooling efficiency of the sheet-like member by the cooling roller is achieved.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. A cooling device comprising:

an outer tube having an inner circumferential surface;

an inner tube; and

a cylinder having an outer circumferential surface,

wherein an outside flow passage is formed by the outer circumferential surface of the cylinder and the inner circumferential surface of the outer tube, the flow passage being formed in a longitudinal direction of the cooling device, and

wherein a turning back flow passage is formed by the outer circumferential surface of the cylinder and the inner circumferential surface of the outer tube, the turning back flow passage connecting the outside flow passage and a flow passage within the inner tube, and

wherein the cylinder includes an end surface positioned adjacent the turning back flow passage, an entirety of the end surface is oblique and the entirety of the end surface slopes in a same direction from the outside flow passage towards an outer circumferential surface of the inner tube.

2. The cooling device according to claim **1**, wherein the cylinder includes an inner circumferential surface in which the inner tube can be inserted.

3. The cooling device according to claim **1**, wherein the outer tube and the cylinder rotate in different rotational directions from each other.

4. The cooling device according to claim **1**, wherein the flow passage of the inner tube is substantially linear, and wherein the outside flow passage is substantially linear.

5. The cooling device according to claim **1**, wherein a first turbulence generating unit is formed on the inner circumferential surface of the outer tube.

6. The cooling device according to claim **5**, wherein a second turbulence generating unit is formed on the outer circumferential surface of the cylinder, and

wherein the first turbulence generating unit and the second turbulence generating unit are alternately provided along the longitudinal direction of the cooling device.

7. The cooling device according to claim **1**, wherein a turbulence generating unit is formed on the outer circumferential surface of the cylinder.

8. An image forming apparatus, comprising:

the cooling device as set forth in claim **1**.

9. A cooling device, comprising:

an outer tube having an inner circumferential surface; and

a cylinder having an outer circumferential surface, the cylinder including an inner flow passage,

wherein an outside flow passage is formed by the outer circumferential surface of the cylinder and the inner circumferential surface of the outer tube, the flow passage being formed in a longitudinal direction of the cooling device,

wherein a turning back flow passage is formed by the outer circumferential surface of the cylinder and the inner circumferential surface of the outer tube, the turning back flow passage connects the outside flow passage and a flow passage within the cylinder, and

wherein the cylinder includes an end surface positioned adjacent the turning back flow passage, an entirety of the end surface is oblique and the entirety of the end surface slopes in a same direction from the outside flow passage towards the inner flow passage.

10. The cooling device according to claim **9**, wherein the flow passage in the inside of the cylinder is substantially linear, and

wherein the outside flow passage is substantially linear.

11. The cooling device according to claim **9**, wherein the outer tube and the cylinder rotate in different rotational directions from each other.

12. The cooling device according to claim **9**, wherein a first turbulence generating unit is formed on the inner circumferential surface of the outer tube.

13. The cooling device according to claim **12**, wherein a second turbulence generating unit is formed on the outer circumferential surface of the cylinder, and

wherein the first turbulence generating unit and the second turbulence generating unit are alternately provided along the longitudinal direction of the cooling device.

14. The cooling device according to claim **9**, wherein a turbulence generating unit is formed on the outer circumferential surface of the cylinder.

15. An image forming apparatus, comprising:

the cooling device according to claim **9**.

16. A cooling device comprising:

a cooling roller to convey a conveyance material together with an opposing rotator, the cooling roller to cool a conveyance material, the cooling roller includes:

an outer tube having an inner circumferential surface;

a cylinder having an outer circumferential surface, the cylinder including an inner flow passage,

wherein an outside flow passage is formed by the outer circumferential surface of the cylinder and the inner circumferential surface of the outer tube, the flow passage being formed in a direction perpendicular to a conveyance material conveyance direction, and

wherein a turning back flow passage is formed by the outer circumferential surface of the cylinder and the inner circumferential surface of the outer tube, the turning back flow passage connects the outside flow passage and a flow passage within the cylinder.

17. The cooling device according to claim **16**, wherein the turning back flow passage is disposed at outside the conveyance material.

18. The cooling device according to claim **16**, wherein an edge of the cylinder is disposed at outside the conveyance material.

19. The cooling device according to claim **16**, wherein the cylinder includes an end surface positioned adjacent the turning back flow passage, an entirety of the end surface is oblique and the entirety of the end surface slopes in same a direction from the outside flow passage towards the inner flow passage.

20. An image forming apparatus, comprising:

the cooling device according to claim **16**.

* * * * *